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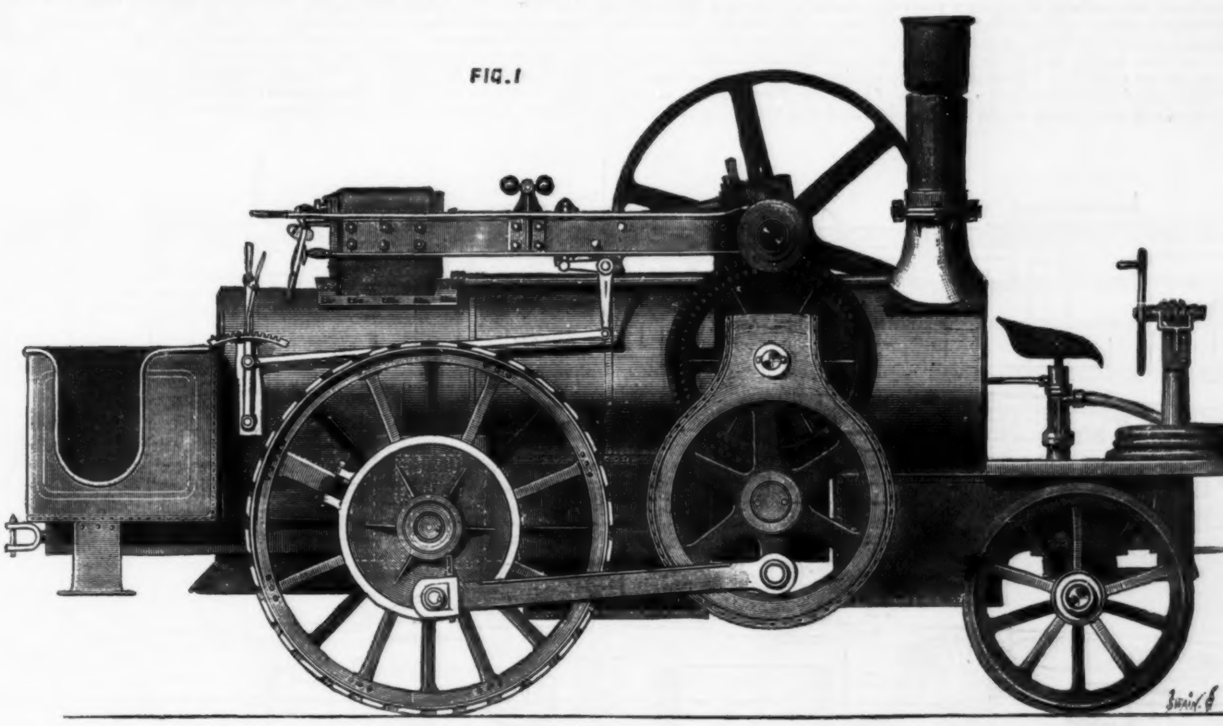
EIGHT HORSE TRACTION ENGINE.

AMONG the exhibits at the recent Bath and West of England show, was Box's patent traction engine, illustrations of which we now give. The general arrangement is shown by the side elevation Fig. 1, and Fig. 2 illustrates the method of carrying the bearings for the crank shaft and the cross shaft upon which are fixed the two crank discs by which the road wheels are driven. The driving pinions on the crank shaft are of malleable iron, arranged as shown in Fig. 2 in such a manner that either the fast or slow speed may be put into gear or the engine allowed to run free, by means of the single clutch lever brought to the back of the cylinder. Figs. 3 and 4 show the arrangement of the governors and guide bars B, supported at their outer ends by the bracket bolted to the distance bars A, A. The side valve passes through and is efficiently guided by the bush in the boss C. All the gearings except the pinions referred to are of steel, the main spur-wheels being of great strength. The main axle and the cross driving shaft under the boiler are each 5·75in. in diameter. The pinions on the crank shaft have respectively 18 and 11 cogs of 2 in. pitch; the intermediate wheel carries two sets of teeth, one of 46 and the other 53 cogs. The intermediate pinion has 12 cogs, and the wheel on the cross shaft 47 cogs of 2·5in. pitch. The crank pins in this and the disc on the other end, which also forms the break sheave, are 3·125in. diameter, and the crank shaft is 3·5in. in diameter.

The boiler is 32 in. in diameter and contains thirty-one tubes, 2·25 in. diameter, giving 120 square feet of heating surface, which, with 29 ft. in the firebox, gives a total 149 square feet of heating surface. The area of the fire grate is 5 square feet. The main road wheels are 5 ft. 3 in. in diameter, and are loose on the axle, power being transmitted through the brake strap, as shown in Fig. 1. The steam cylinder is 9·5 in. diameter, the stroke being 12 in. Two water tanks are provided, one under the smoke-box and the other close to the fire-box, carrying water for a run of twelve miles. The main feature of the design is the use of side connecting roads, by which a good arrangement of springs is secured—some remarks upon which will be found at page 391. Some experience with the engine has shown that the governors render most valuable assistance to the driver, a fact contrary to the general experience with traction engines, and one which may be to some extent accounted for by the assistance afforded by the springs in running over bad roads. The engine is only about 6 ft. 6 in. over all, so that it will pass through all farm gates.—*The Engineer.*

FIG. 1



EIGHT-HORSE POWER TRACTION ENGINE. G. J. FOWELL, ST. IVES, ENGINEER.

FIG. 3

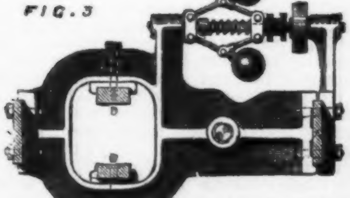


FIG. 4

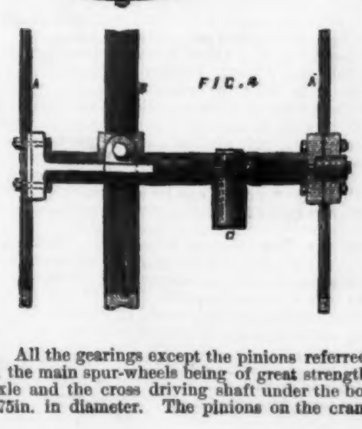
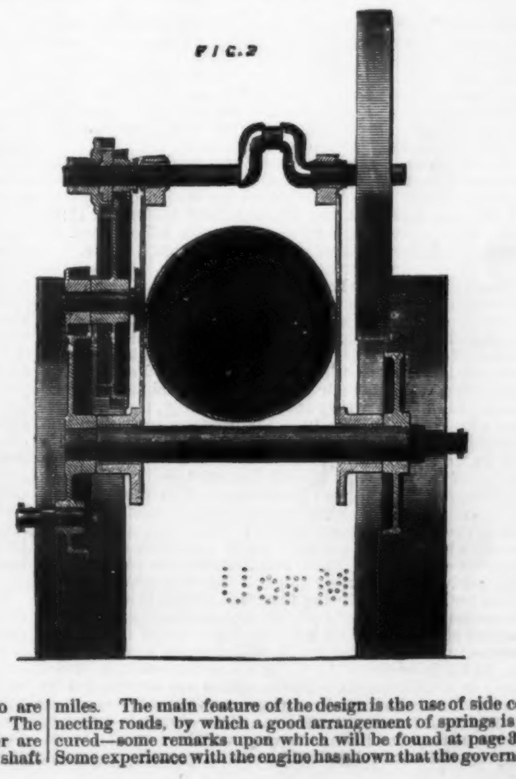


FIG. 2



HOW TO LAY A DRAIN.

By MR. T. MELLARD READE, C.E.

BEFORE treating of the general principles to be followed in house drainage, I may remark that in the selection of the materials of our drains there is now much choice. The use of glazed fire-clay or earthenware pipes is almost universal. Cement pipes have been recommended by an eminent authority, but as I have had no experience of them it is not necessary for me to do more than mention them. No one would now propose to use stone or brick culverts, as were formerly in vogue. Practically, then, our choice of material is limited; but, as usual, there are great variations in the quality of the article supplied not only by different but by the same manufacturers. What the architect should insist upon is a strong, well burned material, accuracy in form both sectionally and longitudinally, true sockets, and a good, smooth glaze. The smaller pipes are especially liable to be twisted longitudinally, and such should at once be rejected. Pipes having a rough interior should not be used, as lumps and blisters in the glaze accumulate material round them, and injure the efficiency of the drain.

At the risk of being accused of putting the cart before the horse, I will also explain the practical art of laying drain pipes, and the fall it is necessary to give them, before touching upon the general question of how to design house drainage. I do this because I consider the proper laying of the pipes one of the most important parts of drainage, and the one in which failures must often occur, and without which any system of house drainage will not perform its functions satisfactorily. The true laying of a pipe is of more importance than its quality. An inferior, rough, and crooked pipe may, if laid properly, under ordinary circumstances be made to perform its work satisfactorily; whereas the best made pipes in the world will only act for a time, and then inefficiently, if laid in those beautiful and horizontal sweeps and undulations known as "Hogarth's line of beauty," so frequently met with when a drain is bared to be taken up, and then only seen in its full perfection.

The righteous indignation of the bricklayer and his laborers employed in taking the drain up, against the tradesman who laid it down, is only fully appreciated when, on having to take it up a second time, we find these honest men have put in a pipe without a socket, or a square junction, or a junction turned the wrong way, or accidentally omitted to make a joint good, or done or left undone some one of those multitudinous things essential to good workmanship. Truly the architect's bed is one more of thorns than roses.

The next thing to be determined on is the fall, and I cannot too strongly insist upon the necessity in all cases of having the levels first accurately taken, and a section made, before the drains are put in. This is an additional trouble, no doubt, but will be amply repaid in the quality of the work. Of course when the whole of the trenches can be opened at once, this is not always necessary; but it more often happens

that the trench has to be filled up as the work proceeds, either from the nature of the ground or the exigencies of the site. The architect should of course aim at getting the greatest amount of fall from the sewer to the junction with the branch drain of the house, keeping in view that these should themselves have quicker gradients than the main drain.

A fall of 1 in 48, or half an inch to a pipe, is a very good one for a main drain; but it sometimes happens that this cannot be obtained; nay, I have myself had to lay them nearly level, but in such cases special flushing arrangements are absolutely necessary. The usual system pursued by the "honest bricklayer" is to start from the main sewer, and lay each pipe to a fall by a straight-edge, with a piece of wood planted on each end. The size of this piece is determined by some rule, no doubt—probably the rule of thumb—a rule, I need scarcely say, of very wide and universal application.

By means of the above-named implements the drain gradually rises toward the house, but whether it hits the exact level, or falls below it, or is a foot or two higher, Providence alone can determine; at all events, I may say it is not so certain to work out right as were the two driftways through Mont Cenis.

It not seldom happens that if the workman finds that he has made a bungle, and has got too high, he either carries his drain on a level or actually dips it the wrong way. And what does the architect do? He sees the end of the pipe at the proper level, and all the rest carefully covered up, and probably assumes that all is right.

There is another internal defect arising from this way of laying pipes; they are laid by the flanges, and the inverts, which are of primary importance, are left to take care of themselves. I have never seen, outside of my own practice, house drains laid by their inverts; but I consider this should, where the fall is limited, always be done. It is readily done, but the drain layer has to be taught, and it is a good deal of trouble to teach him, but no more than I hope any architect interested in the perfection of his work would undertake.

The method of proceeding is by fixing slight rails at the two ends of the drain, and sighting a boning rod, with a T piece at the top and a bent piece of iron or shoe to fit on to the invert at the bottom. This of course usually involves a correct system of levels and bench-marks, with the depths figured on the drawing.

The joints should in all cases be made in cement; half Portland cement and half sand is a good proportion, and special care should be taken to scrape out the cement on the inside of the joint so as to leave as perfect a tube as possible, free from lumps and obstructions. I need scarcely say half-bricks should not be left in the pipes, but I have not unfrequently found them there.

ANALYSIS OF BOILER INCRUSTATIONS.

By Edward Francis.

1. A brown cake, half an inch thick, from a small egg-end boiler, using water drawn from the southwest face of the Anticlinal of Brimington in the middle coal measures. The incrustation was hard, only partially soluble in H Cl (the solution being red), and nearly completely soluble in aqua regia.

The complete analysis shows—

Calcium sulphate	75·65
Silica	5·64
Ferric oxide	4·71
Magnesic oxide	4·85
Loss on ignition (water and organic matter)	8·61
Phosphoric acid	trace
Sodium and potassium	trace
	99·46

2. A very gray cake, about three-eighths of an inch thick, readily pulverized, a portion taken up by water. This was obtained from a boiler fed by water from the Sheffield Water Company's mains. The aqueous solution contained CaMg and H_2SO_4. It was not entirely soluble in HCl, the solution being of a pale yellow color. The subjoined analysis leads to the inference that the water was permanently hard, and that it had little action upon the iron of the boiler.

Calcium sulphate	79·56
Calcium carbonate	5·05
Ferric oxide	1·53
Aluminic oxide	1·02
Magnesic oxide	5·34
Water and organic matter	7·75
Sodium and potassium	trace
Phosphoric acid	absent
	100·25

3. An extremely hard residue, three-eighths of an inch thick, taken from a tubular boiler at Heeley, near Sheffield, the water used being pumped from a well. It was very difficult to powder, but was entirely soluble in aqua regia. The cake in places showed minute specks of metallic iron; these were afterwards dissolved out by iodine solution. A large percentage of ferric acid exist in this incrustation. The following is the complete analysis:

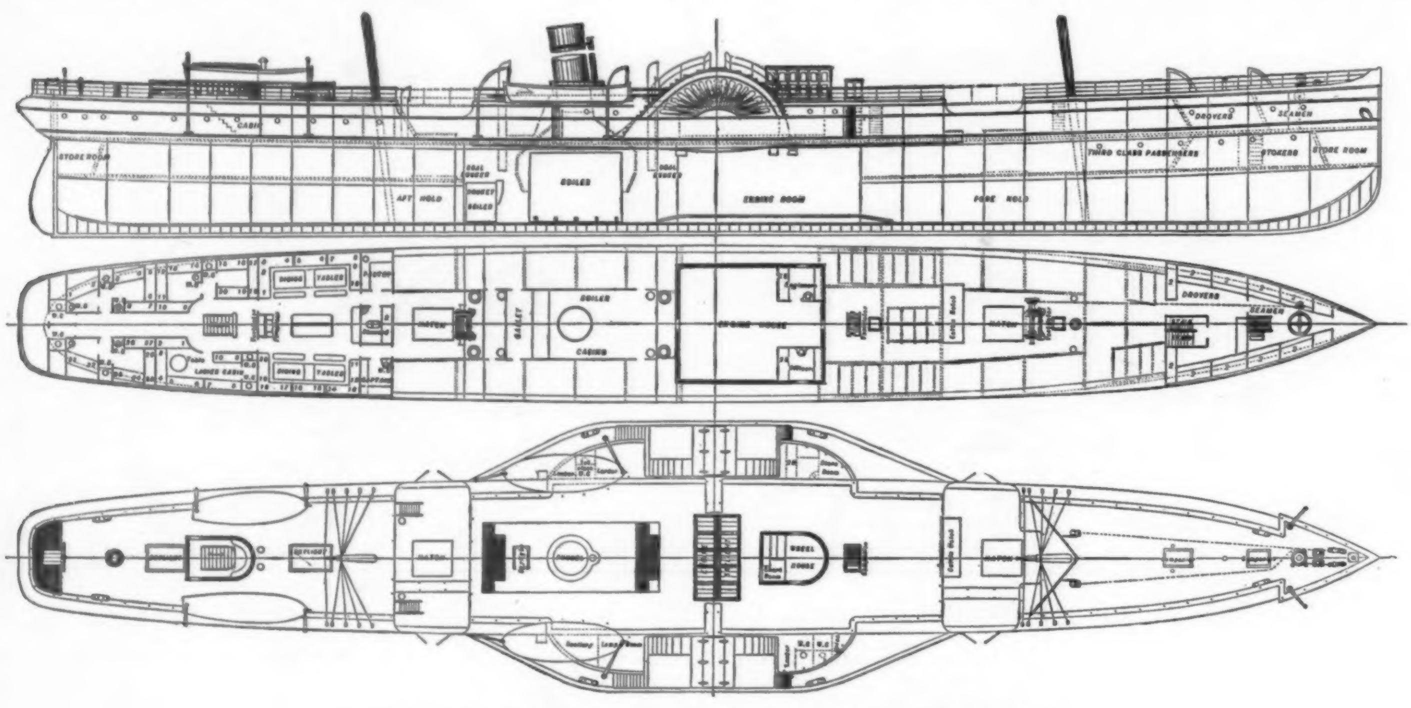
Calcium sulphate	37·06
Ferric oxide	38·98
Aluminic oxide	1·62
Organic matter and water	8·80
Magnesic oxide	10·36
Carbonic acid	2·58
Metallic iron	trace
Sodium and potassium	trace
	99·40

—*Chemical News.*

NEW IRISH MAIL STEAMERS.

For some years, says the *Engineer*, a large traffic has been carried on between England and the South of Ireland by way of Milford and Waterford, steamers being run between these ports by the Great Western Railway Company. Last year the London and Northwestern Railway Company put new and splendid express boats, the Rose and Shamrock, built by Messrs. Laird, of Birkenhead, to run between Holyhead and Dublin; and the Great Western Company, determined that the rival company should not get more than their fair share of the traffic, have now put on improved boats between Milford and Waterford. These boats have been built and engined by Messrs. Simons, of Renfrew. They are three in number, and identical in all respects, except their names, which are Milford, Waterford, and Limerick. They are 1,000 tons burden, and fitted with compound inclined engines, 400 horse power nominal.

The quickest passage on record was made on May 27th, between Waterford and Milford, by the Limerick, Captain William Pearn. The Limerick left the Waterford quay at 5 P.M., and arrived at the pontoon, New Milford, at 11:45 P.M., thus accomplishing the distance in 6 hours and 45 minutes, which is less time than was ever known before.



DIAGRAMS OF THE NEW IRISH MAIL STEAMERS.

Berlin Pneumatic Despatch.—The proposed pneumatic despatch line in Berlin will have 26 kilometers of tube, and 15 initial stations. The wrought iron tubes have a clear breadth of 65 millimeters, and lie about one meter below the surface of the ground. The letters and cards which are to be forwarded have a prescribed size, and are enclosed in iron boxes, or cartridges, each of which can hold 20 letters or cards. In order that they may pack closely, they are covered with leather. From 10 to 15 cartridges are packed and forwarded at a time; behind the last cartridge is placed a box with a leather ruffle, in order to secure the best possible closure of the tube. At four of the stations are the machines and apparatus needed for the business. The forwarding of the boxes is effected either through compressed or rarefied air, or through a combination of the two. Steam engines of about 12 horse power are used for the condensation or exhaustion of the air. Each main station has two engines, which drive a compressing and an exhausting apparatus, the steam for each engine being furnished by two boilers. Large reservoirs are employed both for the condensed and for the rarefied air. The former has a tension of about three atmospheres; the latter, of about 35 millimeters of mercury. The air, which is heated to 45° C. by the compression, is cooled again in double-walled cylinders which are surrounded by water. The boxes travel at 1,000 meters per minute; a train is despatched every 15 minutes. Each circuit is traversed in 20 minutes, including stoppages. The cost of the enterprise will be about $300,000.

DISCONNECTING COMPOUND ENGINES.

We give engravings showing engines for driving twin screws, the perspective view having been prepared from a photograph of engines lately made by Messrs. Rankin & Blackmore for the twin-screw tug-boat Otter, belonging to Messrs. John Laird & Sons, of Port-Glasgow.

The complication entailed by the ordinary arrangement of two cylinders to each shaft has hitherto deterred the owners of twin-screw tug steamers from adopting compound engines notwithstanding the advantages of these engines in other respects, but by Mr. Rankin's plan the compound system is rendered available without involving any more complication than the use of ordinary single-cylinder engines. As will be seen from our engravings there is in Mr. Rankin's engines but one cylinder to each screw shaft, the high-pressure cylinder being placed over one shaft and forming with its connections a purely non-condensing engine, having neither condenser nor pumps, while the low-pressure cylinder stands over the other shaft, from which the air, circulating, bilge, and feed pumps are worked. The surface condenser is situated between the two engines, but is of course connected to the low-pressure engine only.

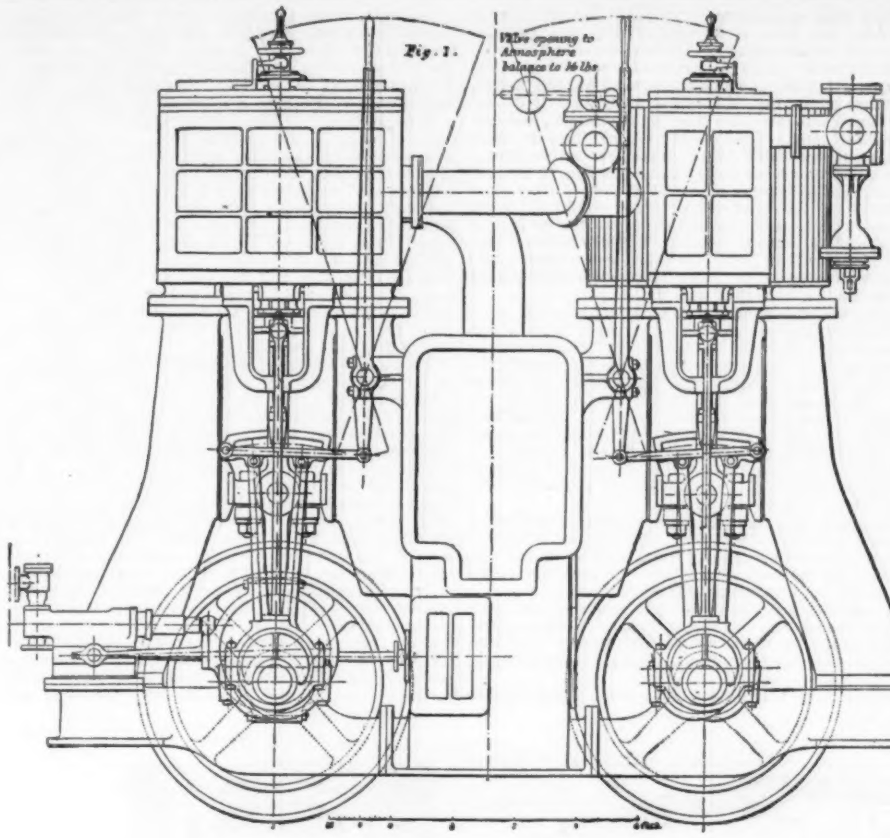
In the engines of the Otter the cylinders are 13 in. and 24 in. in diameter respectively, the stroke in both engines being 20 in. Both cylinders are fitted with expansion valves which cut off at from ¼ to ⅞ of the stroke to suit the variations of power required, an important point in a towing vessel. The valves are also useful for enabling the power developed in the two engines to be equalized and the two propellers to be thus driven at the same speed. The engines drive two propellers each 6 ft. in diameter, and to keep these propellers within the lines of the vessels they are slightly overlapped, working through a screw space formed in the ordinary way. This arrangement enables the tug to be brought alongside a wharf or other vessel without risk of the screw blades striking.

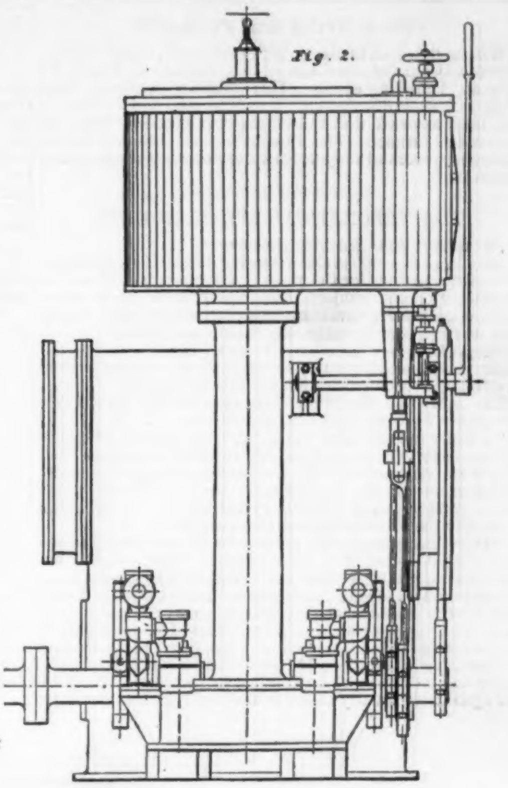
When the engines are connected and working in the ordinary course (that is placed in communication by their steam connections, the two shafts not being connected in any way) the high-pressure engine exhausts into the low-pressure engine, which in its turn exhausts into the surface condenser in the usual manner. But when the engines are disconnected and working separately for the purpose of manœuvring the vessel in harbors, &c., the high-pressure cylinder exhausts through the receiver safety valve—which is loaded to 15 lb. per square inch—direct into the waste-steam pipe. On the other hand, when the low-pressure engine is used alone, the steam is admitted to its valve casing through a reducing valve which is loaded to 16 lb. per square inch, the exhaust steam passing into the surface condenser as usual.

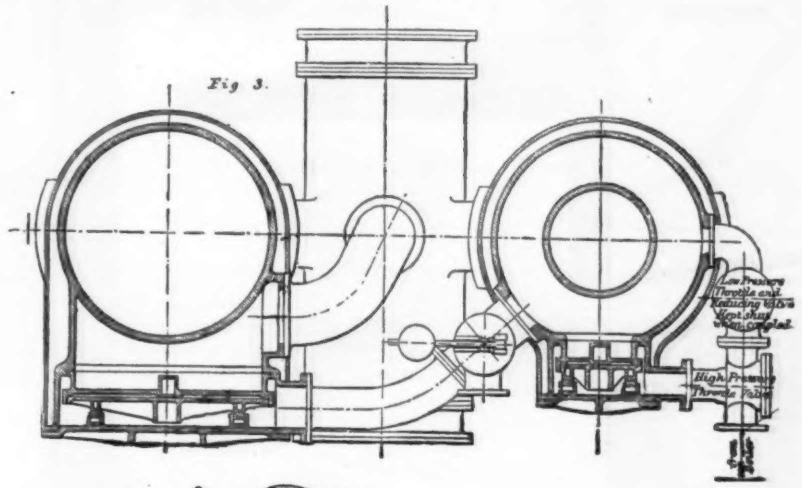
In the case of the Otter, to prevent the engine from sticking on the center, the makers fitted each screw shaft with balanced flywheels, as shown, these flywheels being provided with suitable tripping gear. In practice, however, this has been found almost unnecessary, and we believe that further experience will fully confirm this. The great secret in handling single engines is never to use the throttle valve, but to stop and start them by the reversing lever alone; if this plan be followed it is but very rarely that an engine will stick on the centre, and it will be found that it can be stopped, started, or reversed promptly and easily.

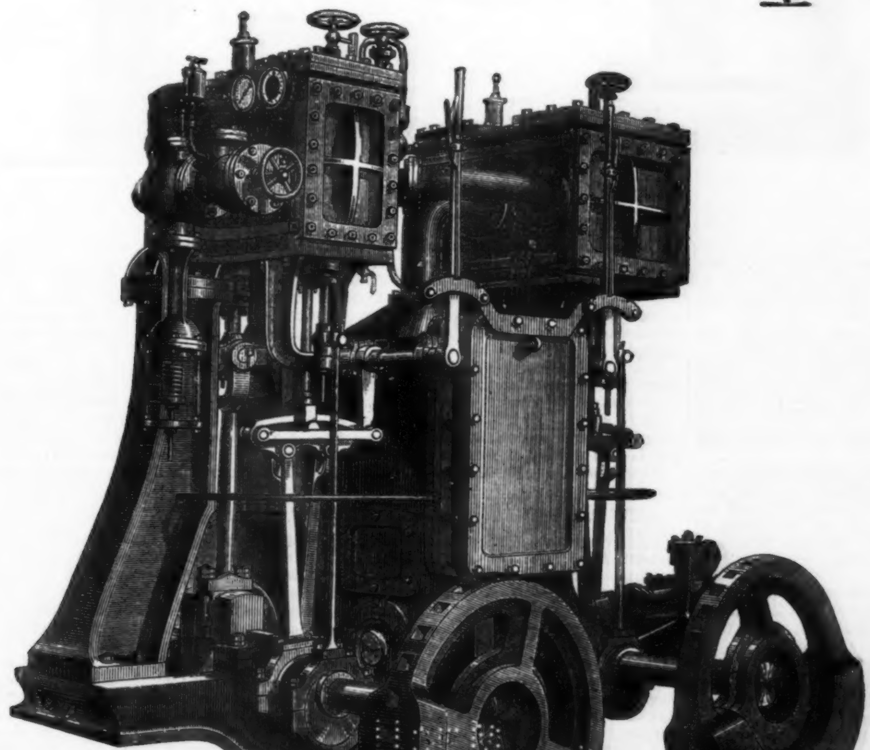
The engines of the Otter have we hear proved perfectly successful, and Messrs. Rankin & Blackmore have now other pairs in hand for other boats, one pair being of double the power of those supplied to the Otter. Although so far these engines have been applied only to tug-boats, yet they are undoubtedly applicable to larger vessels, and they possess advantages which recommend them for adoption on board trading steamers, one of the chief of these advantages being that either engine can be conveniently worked independently in case of a breakdown.—*Engineering.*

Improved Tug Steamers.—Messrs. Howden & Co., Glasgow, now supply improved tug steamers, having two propellers, one at bow and one at stern; immersion to which is given by a novel and suitable formation of the hull, both propellers being larger than could be fitted in the stern of an ordinary screw steamer of same displacement. The effect of this arrangement is to give two large and independent columns of water for resistance, and a hauling power double that obtained from a paddle, single, or twin screw steamer with the same expenditure of engine power.





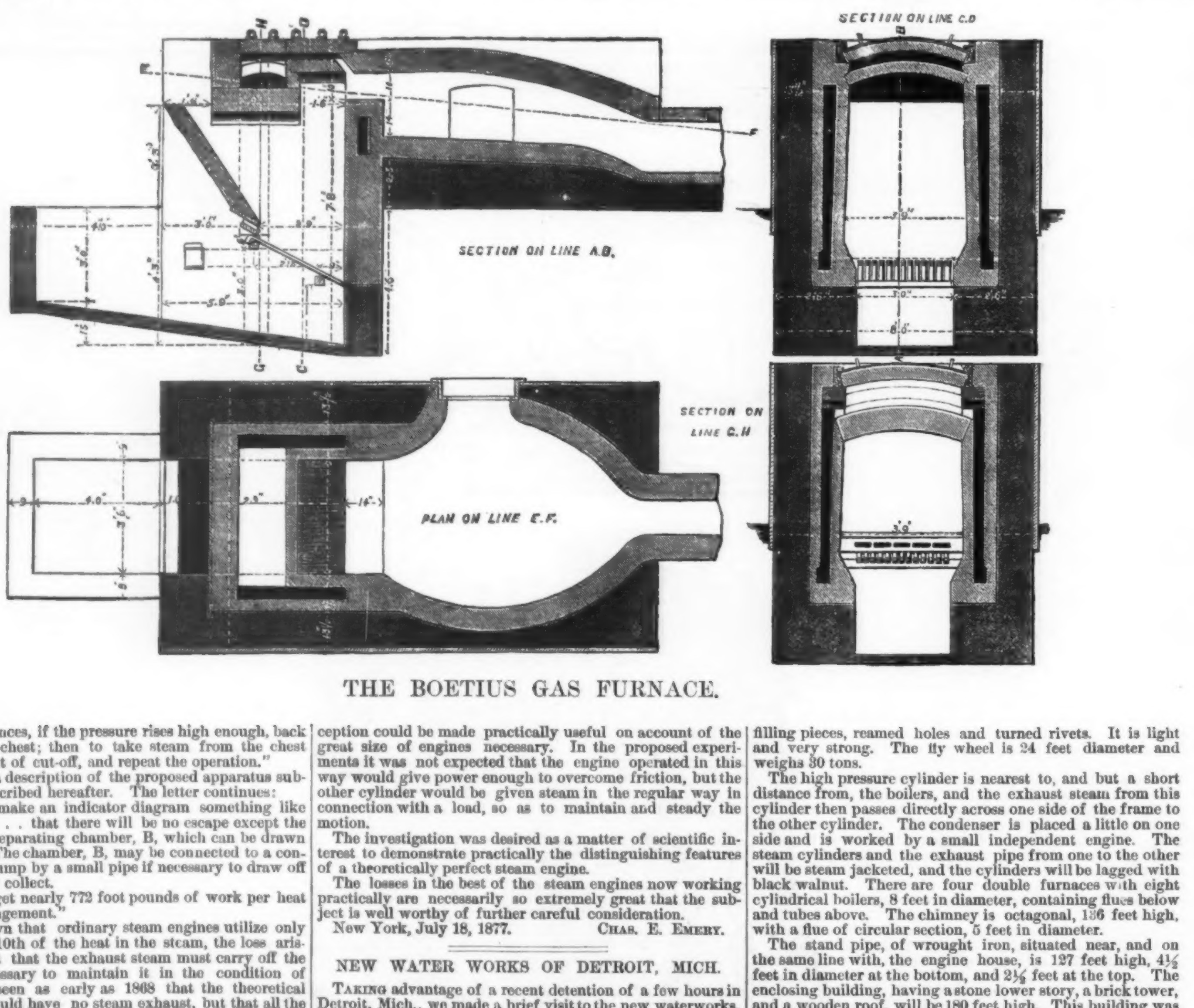




DISCONNECTING COMPOUND SCREW ENGINES OF THE "OTTER." BY RANKIN & BLACKMORE.

THE BOETIUS GAS FURNACE.

We are indebted to Mr. J. F. Boetius, of Clyde Wharf, Victoria Dock, for drawings of this furnace, of which we give an engraving above. This drawing explains itself without further description. It will be remembered that it has been asserted that this furnace is identical with the Bicheroux furnace. The Boetius furnace has, we understand, been worked for years with satisfactory results.—*Engineer.*



THE BOETIUS GAS FURNACE.

THE THEORETICAL STEAM ENGINE.

To the Editor of the Scientific American:

Sir: In preparing several extensive series of experiments with steam engines for the press, I am reminded of an improvement on the subject, made by me some years since, based upon modern developments in thermo-dynamics, which may interest your investigating readers and prompt them to exertions in a new direction. I cannot more concisely describe the proposition than by extracts from a letter written to a friend a few months after the first conception.

The letter was dated "Novelty Iron Works, New York, November 14, 1868," and runs as follows: . . .

"I desire to leave with you a brief description of one of my recent inventions, and possibly the most important one. . . . I am now engaged in constructing a double cylinder arrangement for my experimental engine. The new idea can be tried in one of the new cylinders, . . . and I intend to modify the construction for that purpose. . . .

"Heat disappears in the production of mechanical work. The exhaust steam of an engine always carries away a very large percentage of the heat which enters the cylinder. . . . Former improvements can in no way save this loss. I propose now to make an engine without any exhaust . . . by using high pressure steam in a cylinder with a great deal of expansion, and then exhausting or pushing the steam into a separating chamber, and there separating from it the water due to the loss of heat in work; then to fill the cylinder again from the dry steam in the separator and compress it into the clearances, if the pressure rises high enough, back into the steam chest; then to take steam from the chest again to the point of cut-off, and repeat the operation."

Then follows a description of the proposed apparatus substantially, as described hereafter. The letter continues:

"I expect to make an indicator diagram something like this. I expect . . . that there will be no escape except the water from the separating chamber, B, which can be drawn off by a trap. The chamber, B, may be connected to a condenser and air pump by a small pipe if necessary to draw off any air that may collect.

"I expect to get nearly 772 foot pounds of work per heat unit in this arrangement."

It is well known that ordinary steam engines utilize only about 1-9th to 1-10th of the heat in the steam, the loss arising from the fact that the exhaust steam must carry off the latent heat necessary to maintain it in the condition of steam. It was seen as early as 1868 that the theoretical steam engine should have no steam exhaust, but that all the heat should be expended in work.

I was at the time constructing an experimental compound engine with the two cylinders connected by a large intermediate chamber. In order to demonstrate the correctness of my views in regard to a theoretical steam engine, the chamber mentioned was arranged so that it could be disconnected from the large cylinder, and two compartments were formed in it by a diaphragm which extended nearly to the end farthest from the small cylinder. The latter cylinder was provided at each end with an independent slide valve of ordinary pattern, and the exhaust passages from the two ends of cylinders were separately connected to the chamber through light check valves, one for each end, opening *from* the cylinder to one side of the diaphragm in chamber, and two other check valves opened from the other side of the diaphragm in chamber *to* the independent exhaust passages in cylinder.

It was provided that the valves for each end of the cylinder be moved separately, so as to produce the following operations, after all parts had reached average condition. First, steam at a maximum pressure of 80 to 100 lbs. would be admitted from steamchest to cylinder, cut off short, at say ⅛ stroke, and allowed to expand freely to a pressure below that of the atmosphere. By this operation the steam would be chilled by the performance of work and particles of water resulting from condensation be suspended therein. On the return strike, this steam and water were to be discharged into chambers on one side of diaphragm, and during the redirect stroke dried steam received from the other side of diaphragm, which steam, on the next return stroke, would be compressed; but having lost a portion of its heat in the performance of work and most of the resulting water of condensation, the compression curve would fall below the expansion curve, and pressure either not rise as high as originally, or fill a smaller portion of the cylinder at that pressure. Upon repeating the operation, the cylinder would receive only the amount of steam required to maintain the initial pressure to the point of cut-off.

The pressures in cylinder available for external work would be the differences between those given by the steam expanding freely under the actual thermal conditions and those resulting from the compression. (See diagram above.)

Both ends of the cylinder would be operated in similar manner. The chamber was of sufficient size to prevent material change in the pressures, which fact also insured that the steam discharged would be for several strokes in transit through the chamber, giving the water time to separate. It was provided to put numerous plates of metal in the main passages of the chamber, so as in effect to strain the water out of the steam as it passed through.

The cylinders and chamber, with diaphragm and check valves, were actually constructed. The engines were first tried on the compound system, when lack of means prevented changing the valve gear to give the irregular movements necessary to demonstrate the new principle.

Live steam heating pipes were put inside the chamber while it was being used for the compound engine experiments, the effects of which would undoubtedly have been tried had the experiments with the theoretical steam engine been carried out as intended.

It is proper to say that I have never thought that the conception could be made practically useful on account of the great size of engines necessary. In the proposed experiments it was not expected that the engine operated in this way would give power enough to overcome friction, but the other cylinder would be given steam in the regular way in connection with a load, so as to maintain and steady the motion.

The investigation was desired as a matter of scientific interest to demonstrate practically the distinguishing features of a theoretically perfect steam engine.

The losses in the best of the steam engines now working practically are necessarily so extremely great that the subject is well worthy of further careful consideration.

New York, July 18, 1877. Chas. E. Emery.

NEW WATER WORKS OF DETROIT, MICH.

Taking advantage of a recent detention of a few hours in Detroit, Mich., we made a brief visit to the new waterworks, for further supplying that city, which are now rapidly approaching completion. These works are situated four miles from the center of the city, in the suburb known as Hamtramck, where the Detroit River flows from Lake St. Clair. The pumping engine was designed and built at the Detroit Locomotive Works. It is arranged as follows: A large conical hollow standard of cast iron, which forms the air vessel, carries on its upper end a walking beam, near one end of which is attached the connecting and piston rod of a vertical, high pressure steam cylinder, while at the other end is connected the piston of the low pressure cylinder, the engine being compound. From the extremity of the beam next to the high pressure cylinder the wheel is driven. Immediately below each of the steam cylinders is a pump cylinder, double acting, with piston, taking water directly from the pits or wells in which they are situated. The passage and connections are very short and direct, so that we should look for good results. Both pumps discharge into the air vessel between them through a great number of valves, and the water is thence carried to a stand pipe by which the decided pressure on the main is secured.

The water is taken from the river through a large inlet pipe of iron which extends in a dredged trench several hundred feet from the shore to about fifteen feet of water. It was laid in sections and bolted together by a diver. The water then flows into a large, receiving basin, which was made partly by dredging and partly by enclosing the area with a double row of sheet piling, filled in with clay; the depth of water is about fifteen feet. A timber bulkhead within the basin, extending nearly across the lower end, is intended to check any current from the flow through the inlet pipe. This reservoir will act as a settling basin, if necessary, although we think that it will seldom be needed for this purpose, and will serve as a source of temporary supply in case of trouble from anchor ice. A square brick shaft at each end of the basin contains valves for shutting both the inlet pipe and the conduit to the pumps. This conduit is of brick, 5 feet in diameter, and leads to a well 16 feet in diameter, whence a branch leads to each of two pump pits, only one of which is at present occupied, by the engine described above.

The pit is 26 feet deep, the pump cylinders being supported on its bottom, and the bearings of the walking beam are some thirty feet above the floor of the engine room. The high pressure steam cylinder is 44" in diameter, the low pressure one is 84" in diameter, the two pump cylinders are 40" diameter, and the stroke of all is six feet. The air chamber, a truncated cone, has a diameter of ten feet at the bottom and about seven feet at the top, and is made of cast iron, in segments bolted together through flanges, inside in the upper part, outside below. The eduction valves of the pumps are all grouped in four rings, around the inside circumference of this air vessel, each tier containing 58 valves, 7 inches in diameter, faced with rubber, rising and falling vertically and held in place by spiral springs. By a man-hole and interior iron ladder access can be had, when desired, to the interior of the air vessel and to these valves. The induction valves are flaps of iron, faced with leather. The pistons of both steam and pump cylinders have metallic packing rings. The walking beam is an excellent one, and made of six steel plates, three on each side, with cast iron filling pieces, reamed holes and turned rivets. It is light and very strong. The fly wheel is 24 feet diameter and weighs 30 tons.

The high pressure cylinder is nearest to, and but a short distance from, the boilers, and the exhaust steam from this cylinder then passes directly across one side of the frame to the other cylinder. The condenser is placed a little on one side and is worked by a small independent engine. The steam cylinders and the exhaust pipe from one to the other will be steam jacketed, and the cylinders will be lagged with black walnut. There are four double furnaces with eight cylindrical boilers, 8 feet in diameter, containing flues below and tubes above. The chimney is octagonal, 136 feet high, with a flue of circular section, 5 feet in diameter.

The stand pipe, of wrought iron, situated near, and on the same line with, the engine house, is 127 feet high, 4½ feet in diameter at the bottom, and 2½ feet at the top. The enclosing building, having a stone lower story, a brick tower, and a wooden roof, will be 180 feet high. This building was designed by J. E. Sparks, Architect, of Detroit.

The pumping house is a handsome, fire-proof structure of brick with sandstone trimmings and iron cornice, the roof being made with iron trusses, from the Detroit Bridge and Iron Company, covered with slates fastened to iron purlins by copper wire. It contains a second pit, ready for another pumping engine when needed; a second boiler house and chimney are also completed.

All of the heavy machinery was placed in position with ease by means of a temporary overhead traveller, and two winches with wire ropes.

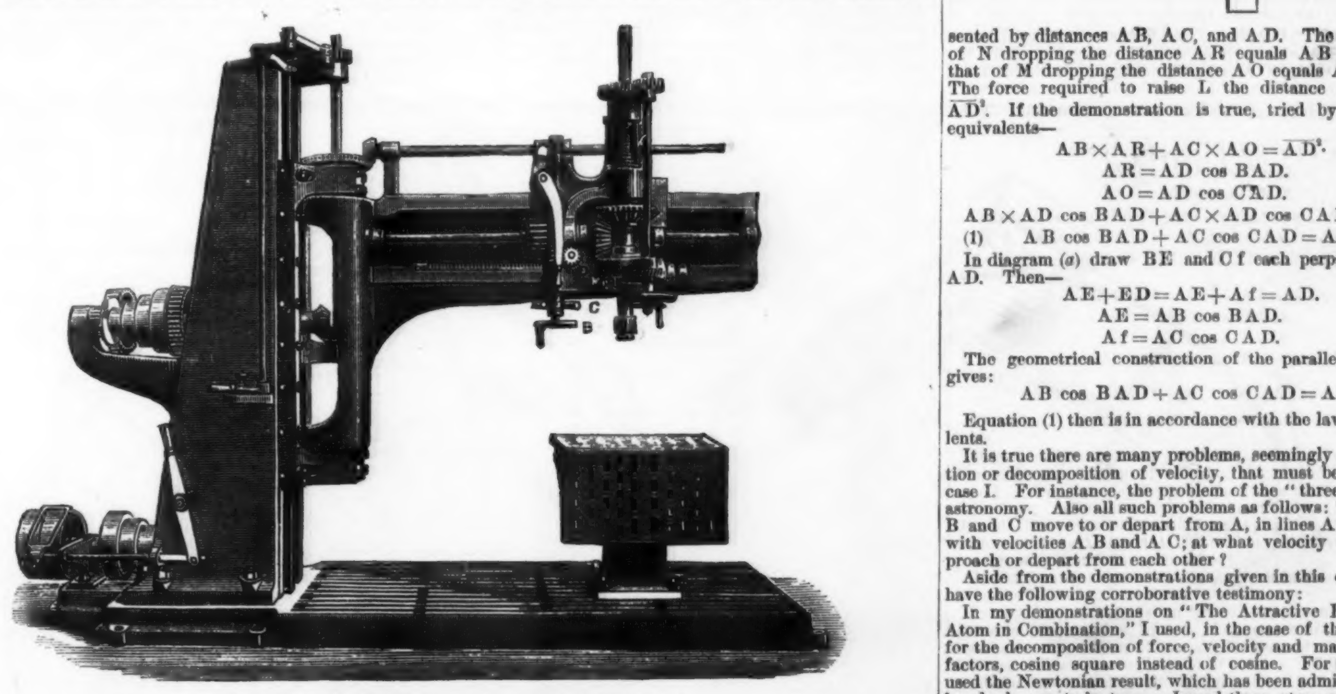
The works have been erected under the supervision of D. Henry Farrand, C. E., the engineer of the Water Commissioners.—*Engineering News.*

A High Level.—The highest point yet attained by any railroad in this country has been reached on the summit of Lavera Pass, in the Sangre de Cristo Mountains, Nev., by the southwestern extension of the Denver and Rio Grande Railroad. The altitude of the summit is 9,340 feet.

RADIAL DRILLING MACHINE.

WE annex an engraving showing a very convenient arrangement of radial drilling machine which has been designed and patented by Mr. William Asquith, of the Highroad Well Works, Halifax. The special feature in Mr. Asquith's arrangement consists in the means provided for shifting the radial arm. Usually, in radial drills, the arm is swung round approximately into the position required by pulling or pushing against the end, a worm wheel, however, being in some cases fixed to the lower trunnion on which the arm swings. This latter arrangement is an improvement, but it is open to the objection that in order to operate the worm-wheel the driller has to leave his work, and he is thus not able to perfect the adjustment without going backwards and forwards, this of course involving a loss of time. It is to avoid this that Mr. Asquith's arrangement has been devised.

Referring to our engraving it will be seen that Mr. Asquith places the gear for moving the slide on the arm, and also that for swinging the arm itself under the immediate control of the workman, who can shift either the slide or arm without leaving his work. Thus by turning the handwheel B motion is communicated through the worm gear shown to the horizontal shaft at the top of the radial arm, this shaft carrying a bevel pinion which gears into a bevel wheel fixed on the frame of the machine concentric with the trunnion of the radial arm. By turning the handwheel B the radial arm is thus caused to move round the fixed bevel wheel, and its position can be thereby accurately adjusted. In the earlier machines constructed on this plan Mr. Asquith provided a clutch lever, as shown, this lever enabling the worm-wheel on the horizontal shaft to be disengaged, and the arm to be thus left free to be pushed round by hand. This provision was made to enable the arm to be quickly moved through large angles, but experience showed that such movements could be as quickly, and more conveniently, effected by the use of his gear, and the disengaging clutch will therefore not be fitted to future machines.



RADIAL DRILLING MACHINE.

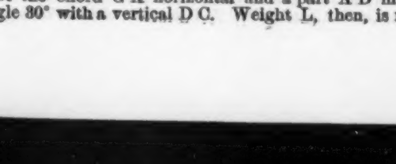
The cross handles, marked C on our engraving, enable motion to be given to a worm gearing into the worm-wheel D, this being fixed on the same spindle as a pinion gearing into the rack shown. By means of the cross handles C the slide carrying the drill spindle can be shifted radially along the arm, and the workman is thus enabled to adjust the drill readily in both directions. The machine we illustrate is self-acting by power for raising or lowering the arm, and the extreme radius of the spindle on the arm is 6 ft. The spindle works in conical bearings which are adjustable and keep the spindle always at right angles to the base plate, while the feed screw is provided with a double nut which can adjusted to take up wear. Altogether Mr. Asquith's radial drill is a very handy and well designed tool.—*Engineer.*

DISCUSSION ON THE PARALLELOGRAM OF FORCES.

By D. P. BLACKSTONE.

I.

Two static forces, pressures, or weights, represented by A B and A C in magnitude and direction, are exactly counterbalanced by a static force, pressure, or weight represented by D A, the diagonal of the parallelogram of which A B and A C are sides.

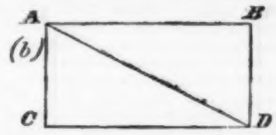


Either one of these parts being known in magnitude and direction and the directions of the other two, the magnitudes of the other two may be determined. For this is all that is necessary to be known to construct the parallelogram.

Experiments with apparatus, represented by diagrams Nos. 1 and 2, prove the above stated proposition. For instance, in diagram No. 1, weight L equals one Lb, M $\sqrt{.75}$ Lb, and N $\sqrt{.25}$ Lb. The result is the weights come to rest with a part of the chord G A horizontal and a part A D making an angle 30° with a vertical D C. Weight L, then, is represented by A D, M by D C, and N by A C. Apparatus represented by diagram No. 2 also comes to rest, having diagonal A D representing weight L, side A C, M, and side A B, N.

II.

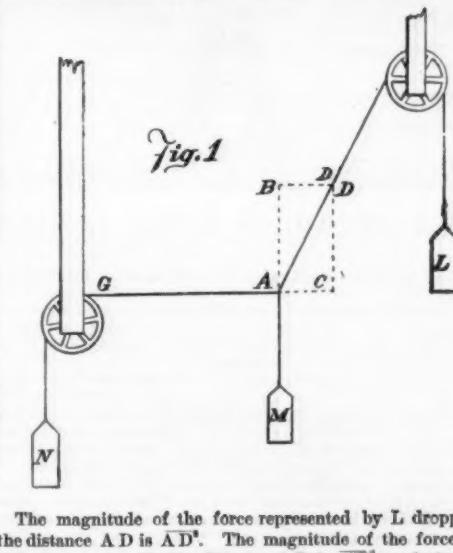
In the case of the rectangle, two forces acting in directions A B and A C, having velocity factors A B and A C,



also weight or pressure factors A B and A C, or represented in magnitude by $\overline{AB}^2$ and $\overline{AC}^2$, are exactly sufficient to produce a force in magnitude $\overline{AD}^2$ in direction A D, having velocity factors A D and weight or pressure factor the same.

In diagram No. 1, let the distance from A to weight M and to the pulleys be infinite compared with A C and A B. Then the distance from A to G is the same as that from B to G, and from A to M the same as that from C to M. Such being the case, it is evident, when the weight L is dropped the distance A D, the weights M and N are raised the distances A B and A C. The velocities of these weights then have the parts of the rectangle for representatives as the weights.

It is the law of the material universe, and beautifully illustrated by the "mechanical powers," that when two weights are in a condition of balance at rest, if a force applied to one gives a certain product of velocity into weight, the same force applied to the other gives an equivalent product of velocity into weight. The law holds true when one weight balances two or more weights.



The magnitude of the force represented by L dropping the distance A D is $\overline{AD}^2$. The magnitude of the force required to raise M the distance A B is $\overline{AB}^2$, and that to raise N distance A C is $\overline{AC}^2$. The test law requires it to be true that

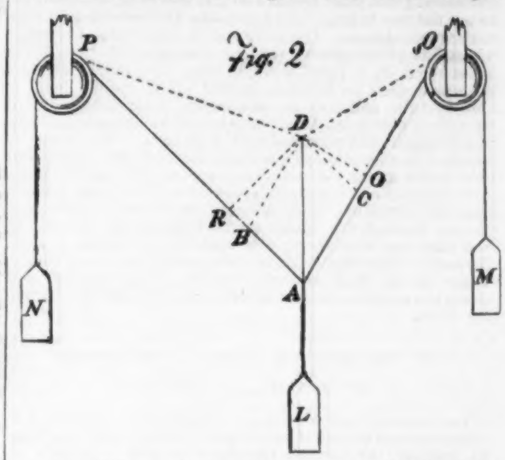
$$\overline{AD}^2 = \overline{AB}^2 + \overline{AC}^2, \text{ or}$$
$$1 = \cos^2 BAD + \cos^2 CAD,$$

which is true per geometry.

In the case of the parallelogram (see diagram *a*), two forces acting in directions A B and A C, in magnitude represented by A B cos B A D and A C cos C A D, are exactly sufficient to produce a force represented by A D in magnitude and direction.

In diagram No. 2 draw D O perpendicular to A Q and D R perpendicular to A P, also draw D Q and D P. Let the pulleys be at such a distance from A that the angles D Q O and D P R become infinitesimate, then D C equals O Q and D P equals R P.

It is evident, when M is dropped the distance A O, and N at the same time dropped the distance A R, that L is raised the distance A D. Each moves with a velocity represented by the distance through which it has moved. It was shown in case I. that the weights N, M, and L are represented by distances A B, A C, and A D. The force, then, of N dropping the distance A R equals A B × A R, and that of M dropping the distance A O equals A C × A O. The force required to raise L the distance A D equals $\overline{AD}^2$. If the demonstration is true, tried by the law of equivalents—



$$AB \times AR + AC \times AO = \overline{AD}^2.$$
$$AR = AD \cos BAD.$$
$$AO = AD \cos CAD.$$
$$AB \times AD \cos BAD + AC \times AD \cos CAD = \overline{AD}^2.$$
$$(1) \quad AB \cos BAD + AC \cos CAD = AD.$$

In diagram (*a*) draw B E and C f each perpendicular to A D. Then—

$$AE + ED = AE + Af = AD.$$
$$AE = AB \cos BAD.$$
$$Af = AC \cos CAD.$$

The geometrical construction of the parallelogram then gives:

$$AB \cos BAD + AC \cos CAD = AD.$$

Equation (1) then is in accordance with the law of equivalents.

It is true there are many problems, seemingly of composition or decomposition of velocity, that must be solved per case I. For instance, the problem of the "three bodies" in astronomy. Also all such problems as follows: Two bodies B and C move to or depart from A, in lines A B and A C, with velocities A B and A C; at what velocity do they approach or depart from each other?

Aside from the demonstrations given in this document, I have the following corroborative testimony:

In my demonstrations on "The Attractive Force of the Atom in Combination," I used, in the case of the rectangle for the decomposition of force, velocity and mass being the factors, cosine square instead of cosine. For the sphere I used the Newtonian result, which has been admitted for two hundred years to be true. I used three steps or logic-links in that demonstration, and reached a result admitted to be correct. Two of those steps or logic-links are admitted to be correct. Then if my third step or logic link is incorrect, the Newtonian result, which in application has always been found to be true, must also be incorrect.

Again, I use the system of cosine square in demonstrations for the spheroids, and reach certain results. I take the average pendulum length near the equator of the earth, and by the spheroid results compute the lengths of the pendulum for all latitudes where pendulum experiments have been made, and the results of computations agree with the experiments as nearly as the experiments at different places on the same latitude.

Again, it had been found that the moon in a certain period of about nine years went ahead of her place in longitude as computed about eight seconds of time, and during the following nine years fell back about the same time. By the spheroid results, I make a computation exactly accounting for this gain and loss of eight seconds.

In closing this paper, I cannot refrain from making a specimen quotation from the books pertaining to composition or decomposition of forces.

"If a *material point* A is acted on by two forces represented in magnitude and direction by A B and A C, there is a resultant, which is exactly represented by diagonal A D of the parallelogram of which A B and A C are sides."

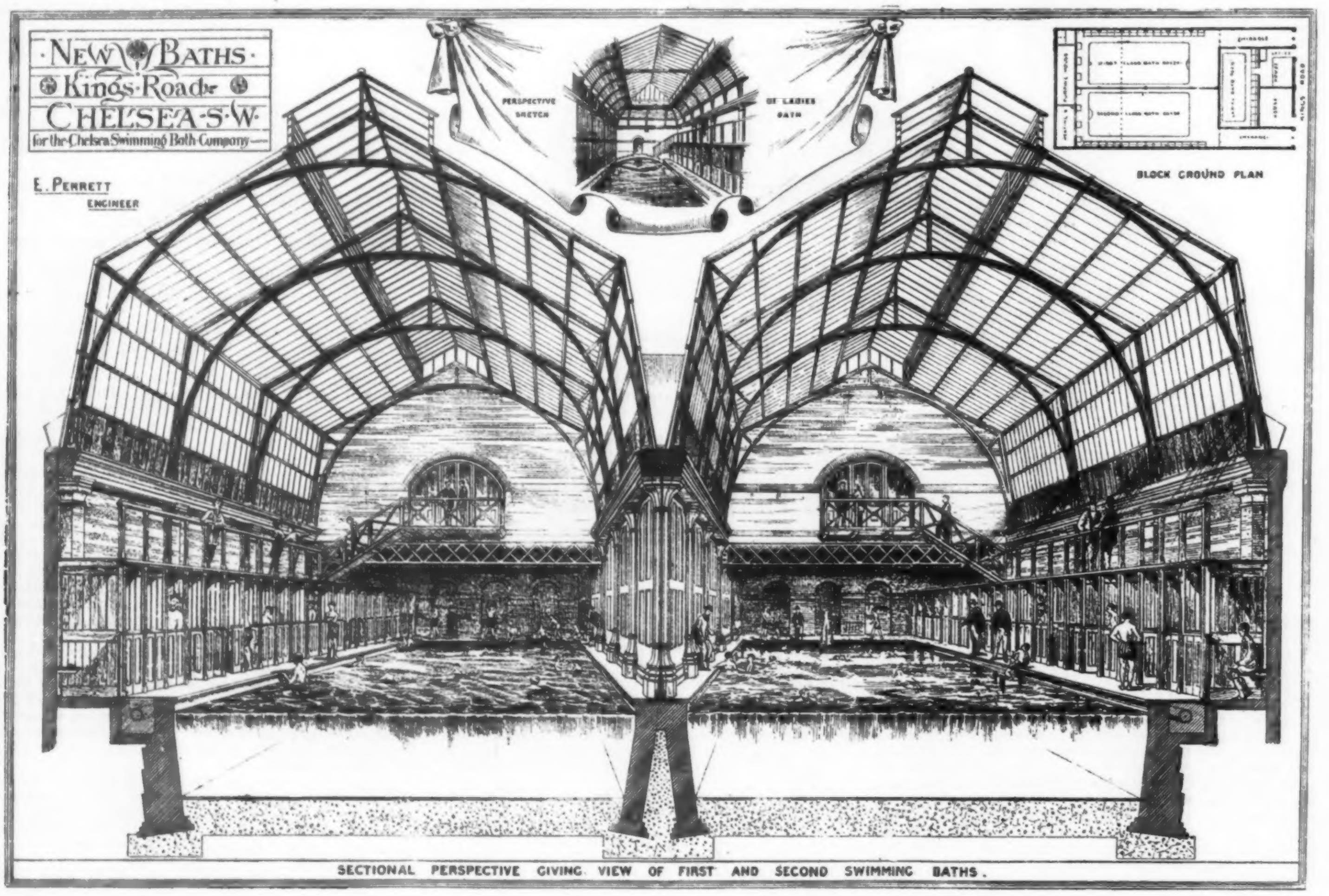
The author of the above gives the results from experiments with weights in equilibrium and at rest, per apparatus represented in diagram No. 2, to verify experimentally the proposition. As well might he have balanced two weights on a stick and called that the law of the working lever. The "*material point*" dodge is remarkably well suited to that kind of demonstration.

Just as long as such demonstration pertaining to force, disregarding the law of equivalents, is accepted, just so long efforts will be made to produce "perpetual motions" or Keely motors.

IRON RAILWAY TIES.—The iron ties on a section of the Central Pacific Railroad consist of circular concave plates, 16 inches in diameter, with a saddle upon the top in which the rail is set, much as in the ordinary chair. The outer half of the saddle is cast with a plate or bed-piece, and the inner half is secured with bolts after the rail is in place. An iron cross-bar connects the plates on opposite sides, the bar having a joint in the centre held by a bolt, with an elastic material in the joint. Elastic materia. is also placed between the rails and the bed-plates. It is claimed that the plates give a better support than wooden ties, and are much more enduring, and hence, although costing twice as much as wood ties, they are more economical. The interest account will probably, after all, settle the question between iron and wood as a material for ties. The mechanical difficulties in the way of a good tie made from iron are small, since by the use of a cushioning material the advantages of wood may be gained where iron is used.

CHELSEA SWIMMING BATHS, LONDON.

OUR illustration of the above shows the three swimming baths. The two baths for men are each 60ft. by 24ft., with a depth varying from 3ft. to 6ft. The sides are of white glazed bricks, and the dressing boxes in each bath are of varnished pitch pine, and is also the movable partition between the two baths. The foot-paths have ornamental tiles with wood edgings. Over one end of these baths is erected a spacious billiard-room, and the remainder of these baths are covered by a light wrought-iron roof, glazed entirely with plate glass on Rendle's system. The ladies' bath is 46ft. by 16ft., and is of an ornamental description, covered by a pitch pine curved roof supported by ornamental cast-iron brackets, and provided with a skylight. The water is supplied in a continuous stream to the first class men's and also to the ladies' baths, flowing out at the opposite ends. Attached to these baths are commodious first and second-class private baths. The builders' work was executed by Messrs. Braid & Co., Manor-street, Chelsea. and the heating and pumping machinery was supplied by Messrs. J. & H. Gwynne, of Hammersmith, the total cost being about £9,000. These works were erected according to the designs and under the superintendence of Mr. Edward Perrett.—*Building News.*



SECTIONAL PERSPECTIVE GIVING VIEW OF FIRST AND SECOND SWIMMING BATHS.

NEW SWIMMING BATHS, LONDON.

ON ICE MAKING AND ICE MACHINES.

By W. N. HARTLEY, F.R.S.E.

THE resolution of all forms of energy into heat, the continual passage of heat through solids, liquids, and gases, and its tendency to become equally distributed through all matter, are now recognized as facts; hence the inevitable conclusion that finally all substances in the solar system, if not in the universe, will ultimately arrive at one common temperature. Mechanical motion, electricity, chemical action, all other forms of energy which at present are sources of heat, will be completely exhausted. Man, by his use of machines, is hastening this end of all things, and this indeed by the production of low as well as of high temperatures.

An economical means of freezing water is a fruitful source of profit at the present time. for the manufacture of ice serves not only the purpose of enhancing our bodily comfort in summer, but also for rapidly cooling large volumes of liquid, as in the operation of brewing and other industrial processes, and for the better preservation of animal food in seasons and climates which hasten putrefactive changes.

The difficulty experienced in freezing water is due to the very large amount of heat it must lose, firstly, in being lowered to the temperature of 32° F., and secondly in being changed from liquid water at 32° F. to solid ice at the same temperature. The first quantity is called its surface heat, and the second is its latent heat. These quantities are greater for water than for any other substance, hence the cooling power of ice is greater for any given temperature than that of any other body, and the cooling power of water is greater than that of any gas or liquid. Faraday calculated that the heat absorbed during the conversion of a cube of solid ice, measuring three feet in the length of one side, into liquid water, without undergoing any rise of temperature, would require the combustion of a bushel of coals for its artificial production.

It is evident from these statements that, in order to cool a quantity of heated air or water down to a moderate temperature, a large supply of water is the best medium, not only on account of its abundance and cheapness, but because of its great capacity for heat.

When any elastic fluid is compressed, it becomes hot, and if it then be cooled down to its original temperature and be expanded, it is rendered as many degrees colder by its rarefaction as it was heated by its condensation; hence we have here a means of producing low temperatures. On the one hand we can ignite tinder by the heat evolved in the compression of air in a glass cylinder; and by the exhaustion of air in a bell jar the temperature may be reduced so that the moisture it contains is deposited as a mist. By the extremely rapid expansion of a liquefied gas when pressure is removed, or of a volatile liquid when its evaporation is hastened by mechanical means, we obtain the most effective cooling powers. The familiar experiment of freezing water or mercury in a red hot dish is effected by the enormous expansion of liquefied sulphurous acid or of solidified carbonic acid, which substances regain the heat they lost when undergoing the change of liquefaction or solidification.

The production of intense cold by the rapid evaporation of ether projected in the form of a fine spray is a process which has been introduced with success into surgery by Dr. Richardson, for the purpose of producing a local insensibility to the pain caused by a knife or other instrument.

By enclosing ether in an air-tight vessel, and drawing off the vapor as fast as it is generated, evaporation is greatly accelerated, while the ether may be condensed again for further use. The original apparatus of Harrison, which depended upon this principle, consisted of a multitubular boiler immersed in an uncongelable liquid, such as brine; an exhaust pump carried off the ether vapor which is rapidly formed at the expense of the warmth of the salt water. The reduction of temperature may reach 24° F., or what is commonly called 8° of frost. The ether was condensed by passing through a worm tube surrounded by a stream of cold water, and the chilled brine was made to circulate round metallic vessels containing the water to be converted into ice.

Many improvements have been made on this ether machine, and one of the most complete methods of working is now in operation on a large scale on the premises of the Manchester Patent Ice Company.

Messrs. Siddeley & Mackay, of Liverpool, are the patentees of the apparatus, the chief characteristics of which are its adaptability to the satisfying of large demands, its economical use of the cooling power of the ether vapor, and its capability of making ice in thick blocks. Not only are exhaust pumps used for evaporating the ether in the refrigerator, but pressure is exerted to liquefy the ether in the condenser. Both refrigerator and condenser are tubular vessels. Now, as the vapor passes from the refrigerator to be condensed by the pump, it is made to part with some of its chilliness either to ether going to the refrigerator, or to water about to be frozen; and again in its return passage to the refrigerator it is deprived of any oil which it may have acquired from the machinery. The whole of the cooling apparatus is below ground, and contained for the most part in pits of cement or asphalte. The water to be frozen is run into metallic tanks, between the inner and outer surfaces of which chilled brine, at a temperature of 15° F., or 17° below freezing point, is made to circulate, the metallic vessels being connected by a stout vulcanized india rubber tubing. The water during freezing is kept in constant agitation, with two objects—first to remove the air, and so obtain clear ice; and second, to equalize the temperature throughout, so as to prevent the water freezing on the surface, as it ordinarily does on a pond. The ice is formed first round the sides of the cell, and gradually thickens till it closes up in the center. The clearness of the ice is greatly increased by slow freezing, and to obtain this desirable condition the time allowed is from 60 to 90 hours. Each block of ice measures 3¼ feet broad by 4 feet long, and 13 inches in thickness; the weight varies from six to seven hundredweight. A simple contrivance, to facilitate the removal of the ice by a crane travelling on rails lain on beams overhead, is a loop of rope which is frozen into each block. The case with which, when placed on the ground, these large blocks can be slid about by the men is very advantageous. In order to loosen the ice from the cells, brine at any temperature above 32° F. is made to circulate in place of the frigorific liquid, and so greatly are the metallic vessels cooled that it requires a period of about an hour to loosen one of the blocks.

The magnitude of the operations is such that the engines can be worked up to 100 horse power, and are capable of turning out 30 tons of ice per day. On the occasion of a recent visit to this interesting factory there were 180 tons of ice in store, and some of the blocks were five weeks old. We have an apparent paradox in the fact that the combustion of one ton of coal in the furnace fires will produce eight tons of ice.

In the last number * of the *Popular Science Review* it was found necessary to refer to the researches of Faraday and others on the liquefaction of gases, and of Professor Andrews on the continuity of the liquid and gaseous states of matter; it is therefore of great interest to note how a purely scientific fact can in a most unexpected way be made available for industrial purposes. No one could have imagined that the liquefaction of gases could prove of any practical benefit to mankind, but we now know that such is the case, since M. Carré's ammonia freezing machine depends upon the liquefaction of the gas by pressure, and its subsequent condensation in water after it has produced a low temperature by its evaporation. The operation is conducted without the application of any mechanical power. A hollow conical condenser of iron has a space between its inner and outer surfaces, which is connected by a tube with a boiler containing ordinary liquid ammonia; that is to say, a solution of about 700 volumes of ammoniacal gas in one volume of water. The conical condenser is immersed in a stream of cold water, while the boiler is heated over a fire or large gas burner to a temperature of 270° F. During this operation the ammoniacal gas is expelled from the water, and is condensed by the pressure of its own particles and the cooling action of the stream of water. If now fresh cold water be placed on the condenser cone, and the heated boiler be cooled in water, the ammonia distils off at the expense of the heat in the water to be frozen, and finds its way back once more to the boiler, ready for another operation.

Leslie's famous experiment of causing water to be frozen by the rapid absorption of heat caused by its own evaporation has been modified by M. Carré, in such a manner that the ice in small quantities, as, for instance, in water bottles, may be made in a few minutes. The apparatus consists of an air pump, to which the water bottle is attached. As the handle of the pump is worked and the air exhausted, a quantity of oil of vitriol is agitated in a vessel, through which all aqueous vapor and air from the water bottle must be drawn. The avidity with which the oil of vitriol absorbs the vapor as fast as it is formed so hastens the evaporation that in a few minutes a bottle of ice is the result.

Perhaps of all machines the one of the most interest is that invented by M. Raoul Pictet, of Geneva, the striking

* See "Mineral Cavities and their Contents."

feature in which is the employment of liquefied sulphurous acid as the absorbent of heat instead of ether. In all other machines there is a liability to a slight leakage, on account of the fact that the cylinder of the exhausting and condensing pump is kept air-tight to some extent by the lubricating material. Now as ether and all kinds of grease are solvents of each other, it is easy to account for a certain amount of escape, which will be difficult to avoid. Liquefied sulphurous acid does not dissolve to any considerable extent in oil, and when free from moisture is without action on metals; and although it might be expected that the packing of the piston might in time be acted on by sulphurous acid, yet this danger has been entirely obviated by the use of manufactured asbestos packing, which is now being greatly used for high pressure steam engines.

When required to work in hot climates, the ice-making machines most generally in use are open to most serious objections, and grave inconveniences are experienced in their constant employment. Thus ammoniacal machines work at a pressure of 20 atmospheres, with water at 80° F., and are thus liable to leakage, or even to the danger of an explosion. Methylated ether machines are open to the same objection, in addition to which there is a danger of fire when a leakage occurs, which unfits them for use at sea.

Now, in the use of sulphurous acid there is the great advantage that at 80° F. its tension does not exceed four atmospheres, while it may be liquefied at 25°, and its tension then is only equal to the pressure of the atmosphere. It has no action upon metals when kept free from water; and in order to obtain it in a perfectly anhydrous condition, M Pictet prepares it by the action of heat on a mixture of oil of vitriol and sulphur, the gas being dried by oil of vitriol. The condensing and refrigerating apparatus consists of tubular vessels similar to those employed with other liquids, such as ether.

4. For all liquids, the difference between the latent heat at any two temperatures, multiplied by the molecular weight, is a constant number.

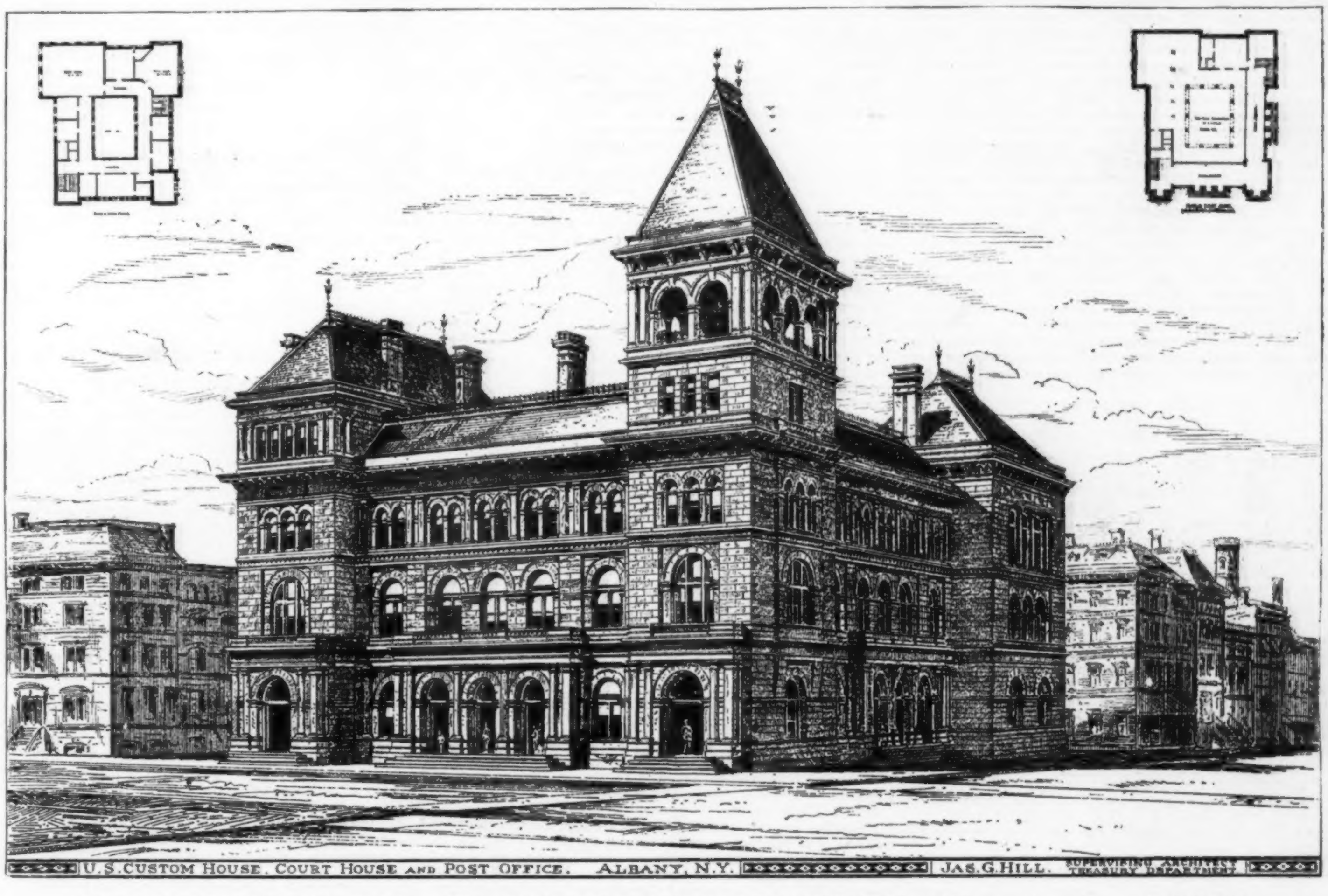
5. The latent heat of every liquid is a multiple of its specific heat.

It would be entering too much into detail to give the method by which these very important conclusions have been arrived at, but it may be of interest to some readers to know that an article on the subject was published by M. Pictet in the last volume of the "Philosophical Magazine."—*Popular Science Review.*

THE MANUFACTURE OF GONGS.

The effect of hammering renders Chinese gongs extremely brittle, a sharp, sudden blow causing them to fly to pieces like glass. The Chinese, therefore, use them with great care near the outer edge, tapping them gently with a padded stick, and cause the vibrations to increase very gradually until their full sound is evolved. When by accident they are broken, the pieces are collected with great care for the fabrication of new gongs. These pieces are heated to a dull red, and when cooled are easily broken into fragments. The best of these are selected, and, being mixed with the metal scraped off the gongs in the manufacture, are melted in common crucibles like those used in England, each crucible containing 7 lbs. or 8 lbs. of the metal, in a special furnace which holds two crucibles. The fuel used is a kind of short-flamed coal, something like anthracite in appearance. The combustion is conducted with much care, the coal being placed around the crucibles by means of large tongs through a circular aperture in the furnace; and the heat is maintained by means of a simple blower, which consists of a long rectangular box with a wooden piston and clappers.

where there is a furnace about 4 ft. in diameter, heated with charcoal, and furnished, like the former, with a blowing-box. A skilled workman, who is seated by the furnace, removes the disk from the latter at the critical moment to an anvil close at hand, and guides it while it is being hammered. On one side is a cistern of cold water, level with the floor of the shop, and on the other is a simple machine on which the disk is clipped round the edge by a cold chisel. While being heated, the workman turns the partly-formed gong round and round and over and over on the mass of incandescent charcoal, so that the metal may be heated thoroughly throughout; and when on the anvil—which, like the former, is a mass of cast iron—it is directed by the chief workman and beaten by five men with hammers and long handles. A peculiarity in the arrangement is that three of the men hammer continually in regular rotation, while the other two wield larger hammers, but beat in unison with the rest. The ability and precision which these men show with their heavy hammers is said to be marvellous. The chief workman stops the operation when the sound of the metal tells him when it is getting cool, places it again in the furnace, and, when sufficiently heated, it is hammered a second time in the same manner. When this is done the gong is nearly of the proper form, and five or six in the same stage of fabrication are then heated together, on the anvil. While this is being performed, all the five strikers aim at the same spot, the fireman turning and directing the work. By this system all the gongs are brought to the same shape and thickness one with the other. But the hammering is continued even after this, the two strikers exchanging their heavy hammers for wooden mallets with flat faces; this hammering is continued for a long time—three-quarters of an hour, says M. Champion, for gongs only 20 in. in diameter. Finally, the gongs are separated, and each one again hammered alone—principally, it would appear, in



THE NEW POST OFFICE AND CUSTOM HOUSE, ALBANY, N.Y.—(*From American Architect.*)

One of these machines is daily at work at the Chelsea Ice Rink, and is capable of making 40 tons of ice per day. The skating floor, which is the invention of Mr. John Gamgee, consists of a number of flattened metallic tubes placed side by side on a bed of concrete or asphalte; the interior of the tubes is kept filled with an uncongelable mixture of glycerine and water, which is allowed to flow in from an elevated cistern. Clear ice is secured by coating the tubes with water spray, allowing this to freeze, and then sprinkling again. During last winter, tubes of thin sheet iron were laid on the floating bath on the Thames, at Charing Cross, and a skating floor was frozen. The temperature of an ice rink from its agreeable coolness has an exhilarating and bracing influence, which dissipates the languor felt in a warm, moist atmosphere.

M. Pictet's machine has interest beyond that of any ordinary economical producer of ice, for, constructed as it is with all the philosophical thought and scientific knowledge which we usually find bestowed only on instruments of research, it has been applied by its inventor to the purpose of establishing certain simple relations between the latent heat, molecular weights, and tensions of the vapors of volatile liquids.

By the application of mathematical reasoning and the use of known data, M. Pictet calculates the latent heat of various liquids, and arrives at the following conclusions:

1. Cohesion is a constant quantity for all liquids.

2. The derivate of the Napierian logarithm representing the ratio between vapor tension and temperature, is constant for all liquids, when they are compared under the same circumstances of pressure and temperature.

3. The latent heat of all liquids referred to one and the same pressure, multiplied by the molecular weight referred to a uniform temperature, gives a constant product.

When the contents of a crucible are melted, the latter is taken from the furnace and weighed, and as soon as it is emptied it is refilled and replaced in the furnace. The temperature is very high, and it is in the upper part of the furnace that the broken metal is heated to redress, as already stated.

When melted, the metal is well stirred in the crucible before being turned out, the oxide and scum being at the same time carefully removed from the surface. It is then poured out into a mold, which consists of a disk of iron lying on a stone slab, and on which is placed a rim of clay to form the edge of the mold. The whole is then greased with oil obtained from oleaginous peas and sprinkled with fine sand; a cover of burnt clay is placed on the moist clay ring, and an orifice at the top of the cone is fitted with a funnel, through which the molten metal is poured. The object of all this arrangement is double; it prevents the metal cooling too rapidly in the mould, and it protects the workmen from the spitting of the metal. When the metal is set, but still red, the cover and the clay are removed, and the cake, which is less than half an inch thick, is well scrubbed with a sort of a wooden brush on both sides to remove all impurities.

The first hammering is performed while the gong metal is still red, on a piece of cast iron about 6 in. high and 10 in. to 12 in diameter, and mounted on a block of wood. The disk is then beaten with a hammer which has a spherical head, and which, having a long and flexible bamboo handle, allows the workman to strike a hard but not dead blow. Two men are employed in this operation, one wielding the hammer and the other turning the metal disk in such a manner that it is gradually rendered concave. When this first hammering is finished, a disk of 14 in. diameter is raised to 2¼ in. to 3 in.; the piece is then carried into another shop,

order to make any corrections in form—and the edges are carefully pared with a cold chisel. At this stage the gongs are very brittle, clippings being easily broken between the fingers; they are, therefore, heated to dull redness, and plunged for a few seconds in cold water, which is said not to contain any added substances to aid in the tempering.

The gongs are then taken into another shop, where they are scrubbed with a woolen rag and salt water; the water in evaporating leaves a small amount of salt on the metal, and the gong in this condition is again placed in the furnace, turned about in every direction, and again hammered. When the central portion of the gong is finished, the edges alone are heated, in order that any faults may be corrected. During these last operations, in order that the action of the fire may be more regular, and that no heat may be lost unnecessarily, a large sheet-iron cover, suspended to a bamboo handle, is held over the gong while in the fire, and is lifted from time to time to allow the firemen to see and turn the work.

Still the work is not yet completed: the edge of the gong has to be turned up to the proper angle, which operation is described as requiring the greatest ability in the workmen, for a single false blow would cause the metal to crack. The gong is now heated to redness for the last time, and thrown into cold water, where it is left for two or three minutes, when it is taken out and briskly rubbed with a wooden mallet to remove any oxide or foreign matter that may adhere to the surface. The final correction of the edge of the gong is effected by a workman who sits on the ground, and who uses two hammers with short handles, one to strike with and the other as an anvil. When he has completed his work, another man takes the gong, places it on an anvil about 8 in. square in the face, and with a round-faced hammer,

weighing about 1 lb., with a short handle, passes over the surface, systematically commencing at the center and proceeding by concentric rings to the outer edge. Sometimes, however, the blows are given in the direction of the radii, but the reason of this is not explained. The blows are vigorous, but the wrist of the workman must be elastic, as it were, so that the shock shall not last too long; but, with all possible care, the work sometimes fails at this point, and should a crack occur, which the workman knows immediately by the sound, the piece is thrown with the waste metal. The traces of this last series of blows are generally apparent in the finished gongs, although before leaving the factory they are scraped with steel tools, either entirely or partially, the scraping being always effected from the center to the circle indicated.

The composition of these gongs has been found by the analysis of many specimens to be as follows:—

Copper	82·00 parts.
Tin	17·00 "
Iron	1·00 "
Nickel	traces. "

The last-named metal can only be discovered by operating upon several grammes of the alloy.

In the manufactory inspected, the men were, on account of the excessive heat, working during the night. They were paid fixed sums, and were bound to produce a certain number of gongs; the foreman who had the complete direction of the work received one piastre (about 4s. 6d.) per day, and the workman half that sum. The whole of them worked all but naked.

At Pekin and other places in the north of China, gongs may sometimes be seen a yard and even more in diameter; but these are rarely seen in the shops; they are said to be made in Cochin-China. A remarkably fine example was shown in the Japanese section of the Paris Exhibition of 1867; it was suspended, as usual, by means of silk-covered cords, and was struck by means of a piece of wood weighing probably 20 lbs., which was also suspended with one end opposite the center of the gong. The sound of this instrument was superb. The resonance of gongs varies materially, and the Chinese class their tones as male or female; those which have been subjected to the most careful and prolonged hammering produce the male tones.

M. Champion remarks that the Chinese gong-makers have a careless and apathetic air, but the skill, sureness of hand, and vigor which they exhibit in effecting the above long and tedious operations are surprising; their activity and energy is such that it is questionable whether any European workman could conduct such an operation successfully in the same time. The most celebrated place for the production of gongs is Su-tchou, a town remarkable for many manufactures. The work is not carried on during the hottest months, on account of its laborious nature. The tam-tam is a necessary instrument at all marriages, funerals, public and religious fêtes, in short, in all ceremonies, and even on the occasion of visits of the superior mandarins; the demand for them is consequently enormous, and their production gives employment to a large number of men.—*Metal Work*, by G. W. Yapp.

GARNETS.

Garnets are obtained by various procedures, differing in some cases in the dye-wares employed, and in others in the mordant. The shades produced differ to a marked degree in solidity, in fullness, in lustre. They are obtained with redwoods, such as Lima, St. Martha, sapan, etc., also with orchil, sanders, magenta, aniline-cerise, madder, logwood, sumac, etc.

The chemical agents employed are tartar crystals, alum, sulphate of alumina, tin composition, carbonate of soda, etc.

Garnets, although easy to dry, require nevertheless certain special precautions, both in manipulation and in setting the becks, which must not be neglected, both for the sake of economy and for the reactions between the mordants and the colors. Thus Brazil wood garnets require particular precautions. When the becks are slightly acid, the ware having much affinity for the mordants, the goods absorb the coloring matter well. If, on the other hand, the bath is faintly alkaline, it neutralizes a part of the mordants contained in the goods, and the affinities are less, and a large quantity of ware is needed to bring up the shade. Brazil wood garnets are dyed after a previous mordanting; orchil garnets are dyed in a single operation; those with sanders and orchil, with logwood, orchil, and Brazil wood, with sumac and orchil, with madder and orchil, all require two operations.

GARNET PREPARE.

Into a water put 13 lbs. 2 ozs. sulphate alumina and 8¾ lbs. tartar crystals for 132 lbs. of goods intended for a heavy garnet. Work the goods for an hour and a half, lift at the end of this time, let drain, scuttle loosely, and let them lie over night before entering in the dye-beck. For each additional lot of 132 lbs. refresh the beck with 13 lbs. 2 ozs. sulphate of alumina and 4 lbs. 6 ozs. tartar. Boil up to dissolve the mordant before entering the pieces, and work as already directed.

DYE-BECK.

Prepare a new beck by adding to a water 2 lbs. 3 ozs. sulphate of alumina and 17 ozs. of tartar, and boil up to dissolve the mordants; then enter a single piece (say 13 lbs.), intended for a deep garnet, and work it at a boil for 30 minutes, then lift. Add to the beck 10 pails of decoction of Brazil wood and 15½ lbs. of orchil for 23 lbs. Boil gently, enter the goods previously mordanted as above, and work it for an hour at 158° Fahr., or for light shades at 140° Fahr.

It is necessary to ascertain during the operation if the ware is in sufficient quantity for the shade required. If red tone is needed a little crystals of tartar should be used; but if a more blue shade is wanted, a little carbonate of soda is used a short time before the end of the operation. When a vinous tint predominates the beck becomes alkaline, and the Brazil wood no longer works upon the goods, which attract the orchil alone. In this case it is necessary, on entering a fresh piece in the same beck, to add a little tartar, so as to neutralize the flat, or render it faintly acid, in order that the Brazil may take on. If we work a piece in an alkaline bath, we should be obliged to use half as much more wood as in a neutral or slightly acid beck, and should obtain a less level shade.

When a piece is dyed it is taken out, let drain, and washed. The proportions of the wares must, of course, vary according to the depth of the shades to be obtained. If a very deep garnet is wanted, the pieces, after mordanting, are slightly bottomed with logwood, in order to economize Brazil and orchil. For this purpose a beck is made up with 2 lbs. 3 ozs. sulphate of alumina and 8¾ ozs. of tartar. In this the piece destined for a maroon is worked for 30 minutes at a boil. It is then lifted, and the beck is mixed with the quantity of logwood liquor needful, one to two gallons being enough to ground a very deep shade. The beck being ready, the mordanted piece is entered and worked at a boil for thirty minutes. For all the subsequent pieces grounded in this beck no more mordant is needed.

It is very important not to let the pieces dry after this beck before dyeing in the garnet bath, otherwise spots appear, which are not easily removed.

BRAZIL GARNET.

Very light garnets may be dyed with Brazil alone, preparing them exactly in the same manner as directed for orchil and Brazil garnets. The dye-beck is charged with eighteen pails of a decoction of red wood for a piece weighing 24 lbs. of wool, and it is worked in the beck for 45 minutes at 158° Fahr.

GARNET WITH SANDERS AND ORCHIL.

These garnets are dyed almost without mordant, but require three distinct baths. By means of these three processes we obtain shades as fine as with Brazil wood, and orchil is economized. We begin with preparing a beck of pure water, heating to a boil, and add 11 lbs. of sanders in powder per piece of cloth weighing 24 lbs. The goods are entered and worked at a boil for an hour, then lifted, drained, and folded.

SECOND BATH.

Make up a very clear water and add sulphuric acid till the liquid marks half a degree of Baumé's hydrometer; heat to 77° Fahr. and work for 15 minutes; lift, drain, and wash well with running water. This bath brightens the coloring matter of the sanders, and gives it a rose-colored tone.

THIRD BATH.

Stuff the beck with the needful quantity of orchil, 17½ lbs. being sufficient. If the bath becomes too alkaline it is neutralized with tin-composition and oxalic acid. When the beck is in good condition, the pieces grounded with sanders are entered and worked for 45 minutes at a boil, then lifted and washed.—*Teinturier Pratique.*

ARLONINE BLACKS.

The arlonine is previously stirred up with a little water, and introduced into the dye-beck previously heated to about 176°. We add then oxalic acid to the extent of 5 per cent. of the weight of the wool and sulphuric acid to ¼ per cent. The beck, when well stirred up, ought to take an amber-yellow color. The woolens to be dyed are then introduced, and worked for about ten minutes without any increase of temperature. The heat is then raised to a boil and kept up 1½ hours. If the water takes a color, either greenish, blackish, or blueish, there is a deficiency of acid, and some should be added, but with care, as an excess would hinder the black from working on to the fibre.

After the time mentioned we add to the beck a small quantity of soda crystals previously dissolved. This addition is made gradually, ceasing as soon as the beck takes a blue shade. In this the goods are worked for another good half hour at a high temperature close upon boiling. The black takes on, and the shade becomes full and bright. The goods are then lifted and well washed, when the black will be found perfectly solid.

For jet blacks, coal blacks, etc., for mourning, a little turmeric, fustic, or sumac may be added at the beginning of the process. The proportion of these additions cannot be defined, but must be regulated by the judgment of the dyer according to the shade desired.

The amount of soda crystals to be added at the end of the process is also difficult to indicate. We believe that the proportion of 2 to 3 per cent. of the weight of the wool is sufficient, adding it little by little, and stopping as soon as the beck takes a blue shade.

For the first lot of wool to be dyed, say 100 lbs., take—

Arlonine	80 lbs. to 90 lbs.
Oxalic acid	4 lbs. to 5 lbs.
Sulphuric acid	1 lb.
Turmeric, 2 lbs., or sumac, 5 lbs.	

The beck will then have a yellowish shade; if blackish, a little more acid must be added, carefully avoiding excess.

If a blue-black is required no turmeric or sumac is added, and a little crystallized carbonate of soda is employed.

The dye-beck is preserved for future use, the second lot of 100 lbs. of wool requiring merely 60 lbs. to 70 lbs. of arlonine, 2½ lbs. to 3 lbs. oxalic acid, and ¾ lb. sulphuric acid. A third lot requires still less. The first lot, therefore, will be tolerably dear, the second cheaper, and the further quantities will show a decided saving. Hence for small establishments, where there is not more than 40 lbs. to 210 lbs. of wool to dye black, there is no saving. In large works, where there is always plenty of wool to dye black, there is a marked advantage in the use of new colors. But all dyers will obtain with it more beautiful blacks, free alike from a green reflection, and from foxiness, than by the old system, whilst the wool will be less punished.

The price of arlonine in Belgium is said to be about £1 9s. for 220 lbs.—*Teinturier Pratique.*

ON THE PRINCIPLES OF TANNING.

It was formerly believed that leather was a true chemical combination formed by the hide and the astringent matter. The researches of Knapp have thrown new light upon this question, proving that leather cannot possibly be a chemical compound. He has succeeded in making leather without any tanning matter by merely driving the water out of the pores of the hide by means of chloride of calcium and anhydrous ether, and he has then reconverted this leather into its original state of hide by leaving it to steep in water. The experiments of Knapp show that in tanning the special agents are not absorbed by the hide in an invariable quantity, but that the proportions depend on the degree of concentration and on the nature of the solvent. To penetrate into the hide to enfold the fibres, to cover them with a precipitate by surface attraction—this is the only part played by the tanning principles. Thanks to their presence, the fibres during the drying of the hide do not form a horny mass, but remain supple and flexible. Leather is not a chemical compound, but rather a mechanical mixture. Knapp considers tanning only as a special case of dyeing.—*Hofmann's Report.*

How to extract Broken Screws.—Place the watch-plate in a strong solution of common alum, which will soon dissolve the screws and leave the plate uninjured.

PRESERVING VEGETABLES GREEN.

Two French chemists, MM. A. Guillemare and F. Lecourt, have made a communication to the Paris Academy of Sciences which, besides having great importance from a sanitary point of view, is peculiarly interesting as a scientific application. It is well known that, in consequence of the change of color caused by the application of heat, sulphate of copper is added to give conserved vegetables and fruits a bright green color, and it is quite unnecessary to dilate on the danger of such a practice. But the brilliant green appearance is so attractive to the uninformed that some means of retaining it is a commercial desideratum. MM. Guillemare and Lecourt propose the substitution of chlorophyl, the natural coloring substance of leaves, etc., for salts of copper, and they have communicated the results of their experiments during four years to the Academy.

The chlorophyl continuing in a vegetable disappears by boiling all the more rapidly and completely in proportion to its small amount; but vegetables at a heat of about 100° C., brought into contact with soluble chlorophyl, become saturated with it, and when thus saturated, or only half saturated, they retain their color during cooking.

Those facts having been brought out by experiment, MM. Guillemare and Lecourt proceeded to act upon spinach and other leaves by means of a lye of caustic soda; the liquor thus obtained, treated with common alum, gave a lake of chlorophyl, which was carefully washed to clear it of all traces of sulphate of soda. To render this lake soluble, alkaline phosphate and earthy alkalies were used. Thus a soluble compound was obtained of a rather unstable character, containing chlorophyl, alumina, and phosphate of soda. This liquor was added to the water in which the vegetables to be conserved were boiled, when the chlorophyl was taken up by the vegetables more or less completely, according to the duration of the action. The vegetables were then put up in air-tight tins, and cooked in the usual way.

A glass was exhibited, containing peas which had been boiled in pure water as usual, and then raised to 117° C., and kept at that sufficiently long to ensure their preservation; they had lost their chlorophyl. A second was shown, in which were more peas, which had been half saturated with chlorophyl during the boiling, and then cooked in the same way as the preceding; they retained a green color similar to that given by sulphate of copper. A third glass vessel contained peas which had been completely saturated during boiling, and then cooked in the same way as the others; their color was more natural than that given by copper, and it was said that they had no taint of astringency in flavor.

The experiments succeeded equally with haricots, cucumbers, etc. The Academy has appointed a commission to inquire into the subject by means of a series of experiments conducted on a large, practical scale.

THE REPAIR OF SUBMARINE CABLES.

The result of the expedition which we believe is now engaged in attempting the repair of the long-silent Atlantic cables will be looked for with great interest, not only by the shareholders of those companies which own long lines of cable, but by cable manufacturers also. To the former it will afford an insight into the durability of their property, and will show to what extent the reserve funds of the companies in which they are interested may be expected to be entrenched upon. To manufacturers who have an eye to business the result of the expedition will be of great importance. It will tell them whether they may look forward to fresh orders, either in consequence of the expedition proving futile, and the consequent necessity for new cables to be manufactured at no very distant dates; or should the attempts to repair prove successful it may, by inspiring confidence in the durability of cables, and the possibility of their repair in deep water even after a long immersion, give a considerable impetus to submarine cable enterprise in parts of the world which are at present destitute of telegraphic communication.

The possibility of repairing cables in deep water ceased to be a problematical question after the successful expedition of 1866; and to the breaking—perhaps we might almost call it "fortunate" breaking—of the 1865 Atlantic cable and its subsequent repair is no doubt owing the confidence which has led to so large an amount of capital being sunk in submarine cable securities.

Of the durability of the gutta-percha core of a cable there is, we believe, not the slightest doubt; of the durability of its protecting sheathing sufficient evidence has yet to be brought forward. Portions of cable have been recovered after many years' immersion in almost as perfect a state as when laid down; other portions have had their sheathings completely rotted away, and without any really satisfactory cause being assigned for the decay. Unless this decay can be prevented, the probability of raising a cable encrusted with a mass of half-decayed hemp and iron, which adds nothing to its strength and everything to its liability to break when subjected to the strain of a grapnel, is very small.

That a cable can be hooked by a grapnel at any depth to which it is likely to be laid, has been proved beyond dispute, but that can be raised to the surface with certainty becomes a more doubtful question the longer the cable has been laid down.

To render the repair of deep-sea cables a matter of certainty more attention requires to be paid to their mechanical construction than has hitherto been the case. The point is too often lost sight of that the sheathing of a cable is not so much to enable it to be laid down as to enable it to be raised for repairs. A great deal, we fancy, might be done in the direction of rendering the gutta-percha core of a tougher nature than it is, as at present manufactured. Nearly all the skill in manufacturing gutta percha has been turned in the direction of increasing its insulating property or decreasing its specific inductive capacity. A little attention in the direction of increasing its mechanical strength might prove of value. We believe that there is a great deal to be done in this direction, and that the cable of the future will be one whose principal mechanical strength will lie in its core, which is practically imperishable.

That it would be practicable to lay a deep-sea cable which had no outer protection beyond its gutta-percha covering is, we believe, the opinion of several competent engineers. Gutta-percha has a specific gravity nearly equal to that of water, and consequently the strain which it would have to bear at the surface of the water would not be heavy. The danger lies in sudden strains to which it may be subjected whilst being laid, but these are reduced to a minimum in the smooth-working machinery now employed for paying out.

A cable of this kind once laid down would remain unal-

tered for years, and at any time would be in a condition to stand the strain of picking up.

The advocates of the light cable system had these considerations in view, and although they have received the support of those best qualified to judge upon such matters, their schemes have not as yet received sufficient public support to enable them to be carried out. The result of the repairing expedition we have referred to may, however, go far towards reviving the idea.—*Telegraphic Journal.*

THE STORY OF THE PRISM.

When we see the brilliant colors reflected by the glass lustres and chandeliers which are now so commonly used for decorative purposes, we seldom bestow a thought upon them, regarding them as things too common, perhaps too trivial, to be worthy of any particular attention. We are content to know that a triangular piece of glass will exhibit certain bright colors—they look very pretty, and it does not matter much how they happen to be there. This is the common way of dealing with the natural phenomena which meet us at every turn in this wonderful world in which we live. The progress of civilization, with all its triumphs of Science and Art, would indeed have been slow, if not altogether at a dead-lock, if every one had been content to treat such matters in this summary fashion. But happily, this has not been the case, for certain intellectual giants have from time to time arisen, who have grappled with these things, and have devoted their lives to their investigation.

Such a one was Sir Isaac Newton, who just about two centuries ago, with rough appliances fashioned by his own hands, inquired into the meaning of the colors to which we have just alluded. We cannot do better than quote his own words, from a letter which he addressed to the Royal Society in 1672; for his statement is so clear that a child can easily understand what he means. 'I procured me a triangular glass prisme,' writes he, 'to try therewith the celebrated phenomena of colors. And in order thereto having darkened my chamber and made a small hole in my window-shuts to let in a convenient quantity of the sun's light, I placed my prisme at his entrance, that it might be thereby refracted to the opposite wall.'

He goes on to say how surprised he was to find that the ray of light, after passing through the prism, instead of being thrown upon the wall in the form of a round spot, was spread out into a beautiful colored ribbon; this ribbon being red at one end, and passing through orange, yellow, green and blue, to violet at its other extremity. Upon this experiment is founded the theory of color, which, with few modifications, still remains unquestioned.

It was not until the beginning of the present century that this experiment of Newton's (repeated as it had doubtless been in the meantime by many philosophers) was found by Dr. Wollaston to possess certain peculiarities which defied all explanation. He found that, by substituting a *slit* in the shutter of the darkened room for the round hole which Newton had used, the ribbon of color, or spectrum as it is now called, was intersected by certain dark lines. This announcement, although at the time it did not excite much attention, led to further experiments by different investigators, who, however, vainly endeavored to solve the meaning of these bands of darkness. It was first observed by an optician of Munich that they never varied, but always occupied a certain fixed position in the spectrum; moreover he succeeded in mapping them to the number of nearly six hundred, for which reason they have been identified with his name, as "Frauenhofer's lines."

In 1830, when improved apparatus came into use, it was found that the number of these lines could be reckoned by thousands rather than hundreds; but their meaning still remained a puzzle to all. By this time Newton's darkened room with the hole in the "window shuts" had been, as we have just said, greatly improved upon. The prism was now placed in a tube, at one end of which was a slit to admit the light, while the retina of the observer's eye received the impression of the spectrum at the other end. This is the simplest form of the instrument now known as the spectroscope, and which is, as we have shown, a copy in miniature of Newton's arrangement for the decomposition of white light into its constituent colors.

We must now go back a few years to record some experiments carried out by Herschel, which, quite independent of the spectroscope, helped others to solve the problem connected with the dark lines. He pointed out that metals, when rendered incandescent under the flame of the blowpipe, exhibited various tints. He further suggested that, as the color thus shown was distinctive for each metal, it might be possible by these means to work out a new system of analysis. A familiar instance of this property in certain metals may be seen in the red and green fire which is burned so lavishly during the pantomime season at our theatres; the red owing its color to a preparation of the metal strontium, and the green in like manner to barium. Pyrotechnists also depend for their tints not only upon the two metals just named, but also upon sodium, antimony, copper, potassium, and magnesium. Wheatstone also noticed the same phenomena when he subjected metals to the intense heat of the electric current; but it was reserved for others to examine these colors by means of the spectroscope. This was done by Bunsen and Kirchhoff in 1860, who by their researches in this direction, laid the foundation of a totally new branch of science. They discovered that each metal when in an incandescent state exhibited through the prism certain distinctive brilliant lines. They also found that these brilliant lines were identical in position with many of Frauenhofer's dark lines; or to put it more clearly, each bright line given by a burning metal found its exact counterpart in a dark line on the solar spectrum. It thus became evident that there was some subtle connection between these brilliant lines and the dark bands which had puzzled observers for so many years. Having this clew, experiments were pushed on with renewed vigor, until, by some happy chance, the *vapors* of the burning metals were examined through the agency of the electric light. That is to say, the light from the electric lamp was permitted to shine through the vapor of the burning metal under examination, forming, so to speak, a background for the expected lines. It was now seen that what before were bright bands on a dark ground, were now dark bands on a bright ground. This discovery of the reversal of the lines peculiar to a burning metal, when such metal was examined in the form of vapor, led to the enunciation of the great principle that "vapors of metals at a lower temperature absorb exactly those rays which they emit at a higher."

To make this important fact more clear, we will suppose that upon the red hot cinders in an ordinary fire grate is thrown a handful of saltpetre. (This salt is, as many of our readers will know, a chemical combination of the metal potassium with nitric acid—hence called nitrate of potash, or more commonly nitre.) On looking through the spectroscope at the dazzling molten mass thus produced, we should find that (instead of the colored ribbon which the sunlight gives) all was black, with the exception of a brilliant violet line at the one end of the spectrum, and an equally brilliant red line at the other end. This is the spectrum peculiar to potassium; so that, had we not been previously cognisant of the presence of that metal, and had been requested to name the source of the flame produced, the spectroscope would have enabled us to do so without difficulty. We will now suppose that we again examine this burning saltpetre under altered conditions. We will place the red-hot cinders in a shovel, and remove them to the open air, throwing upon them a fresh supply of the nitre. We can now examine its vapor, whilst the sunlight forms a background to it; when we shall see that the two bright colored lines have given place to dark ones. This experiment will prove the truth of Kirchhoff's law so far as potassium is concerned, for the molten mass first gave us the bright lines, and afterwards by examining the cooler vapor we saw that they were transformed to bands of darkness; in other words they were absorbed. (In describing the foregoing experiment, we have purposely chosen a well-known substance, such as saltpetre, for illustration; but in practice, for reasons of a technical nature, a different form of potassium would be employed.) Kirchhoff's discovery forms by far the most important incident in the history of the spectroscope, for upon it are based the new sciences of Solar and Stellar Chemistry, to which we will now direct our reader's attention.

The examination of the heavenly bodies by means of the spectroscope has not only corroborated in a very marvellous manner the discoveries of various astronomers, but it has also been instrumental in correcting certain theories and giving rise to new ones. The existence of a feebly luminous envelope extending for hundreds of thousands of miles beyond the actual surface of the sun, has been made evident whenever an eclipse has shut off the greater light, and so permitted it to be viewed. The prism has shown this envelope, or chromosphere as it is called, to consist of a vast sea of hydrogen gas, into which enormous flames of magnesium are occasionally injected with great force. (We need hardly remark that these facts are arrived at analogously by identifying the absorption lines with those given by the same elements when prepared artificially in the laboratory.) This chromosphere can, by the peculiar lines which it exhibits in the spectroscope, be made manifest whenever the sun itself is shining.

The foregoing discovery has given astronomers the advantage—during a transit of Venus—of viewing the position of the planet both before and after its passage across the sun's disc; for it is evident that the presence of an opaque body in front of the chromosphere will cut off the spectral lines in the path which it follows; so that, although the planet is invisible, its exact place can be noted. From a comparison of these lines with those that can be produced in the laboratory, it is rendered probable that no less than thirteen different metals are in active combustion in the body of the sun. From certain geological appearances, it is conjectured that our own earth was once in this state of igneous fusion, and although our atmosphere is now reduced to a few simple elements, it must once have possessed a composition as varied as that of the sun. As it is, the air which we breathe gives certain spectral lines. These are much increased in number when the sun is low, and when therefore it is viewed through a thicker medium. In this case the blue and green rays are quickly absorbed, while the red pass without difficulty through the denser mass of air, thus giving the setting sun his blood-red color. It will now be readily understood how, by means of the spectroscope, the existence of atmosphere in the superior planets can be verified. What a world of conjecture is thus opened out to us! for the existence of atmosphere in the planets argues that there are seas, lakes, and rivers there subject to the same laws of evaporation as those upon our own earth. And if this is so, what kind of beings are they who inhabit these worlds? The moon shows no trace of atmosphere, so that we may assume that, if there be living beings there, they must exist without air and without water. The lines given by the *moon* and *planets* being in number and position identical with those belonging to the solar spectrum, is a further proof, if any were needed, that *their light is borrowed from the sun.*

The varied colors of the fixed stars may be assumed to be due (from what we have already stated with regard to metallic combustion) to their chemical composition; and the spectroscope, by the distinctive lines which it registers, renders this still more certain. Their distance from us is so vast, so immeasurably beyond any conception of space that we can command, that the detection of their composition is indeed a triumph of scientific knowledge. It has been calculated that if a model of the universe were made in which our earth were depicted as the size of a pea, the earth itself would not be one-fifth large enough to contain that universe.

If we marvel at the extraordinary skill which has brought these distant spheres under command of an analytical instrument, we must wonder still more when we are told that the spectra of these bodies can be brought within range of the photographic camera. This has lately been done by the aid of the most complicated and delicate mechanism; the difficulty of keeping the image stationary on the sensitive collodion film, during the apparent motion of the stars from east to west, having only just been surmounted. This power of photographing the spectrum is (as we hinted in a recent paper on Photographic Progress) likely to lead to very great results, for the records thus obtained are absolutely correct and far surpass in accuracy the efforts of the most skillful draughtsman. It must be understood that in all these researches the spectroscope is allied with the telescope, otherwise the small amount of light furnished by some of the bodies under examination would not be enough to yield any practical result.

The clusters of matter which are called nebulæ, and which the most powerful telescopes have resolved into stars, are shown by the prism to be nothing but patches of luminous gas, possibly the first beginnings of uncreated worlds. Comet-tails are of the same nature, a doubt existing as to whether their nuclei borrow their light from the sun or emit light of themselves. We may close a necessarily brief outline of this part of our subject by stating that it is possible that the spectroscope may some day supplant the barometer, more than one observer having stated that he has discovered by its aid signs of coming rain, when the latter instrument told a flattering tale of continued fine weather.

We have merely shown hitherto how the spectroscope is capable of identifying a metal; but its powers are not limited to this; for by a careful measurement of the length of the absorption lines, a very exact estimate of the *quantity* present can be arrived at. This method of analysis is so delicate that in experiments carried on at the Royal Mint, a difference of one ten-thousandth part in an alloy has been recognized. Neither must it be supposed that the services of the spectroscope are confined to metals, for nearly all colored matter can also be subjected to its scrutiny. Even the most minute substances, when examined by the microscope in conjunction with the prism, show a particular spectrum by which they can always be identified. Nor does the form of the substance present any difficulty in its examination, for a solution will show the necessary absorbtion bands. Blood, for instance, can be discovered when in a most diluted form. To the physician the detection of the vital fluid in any of the secretions is obviously a great help to the diagnosis of an obscure case. But in forensic medicine (where it might be assumed that this test would be of value in the detection of crime) the microscope can identify blood-stains in a more ready manner.

The simple glass prism as used by Newton, although it is the parent of the modern spectroscope, bears very little resemblance to its gifted successor. The complicated and costly instrument now used consists of a train of several prisms, through which the ray of light under examination can be passed by reflection more than once. By these means greater dispersion is gained; that is to say, the resulting spectrum is longer, and consequently far easier of examination. A detailed description of the instrument would be impossible without diagrams, but enough has been said to enable the reader to understand theoretically its construction and application.

It will be understood that we have but lightly touched upon a phase of science which is at present quite in infancy. It is probable that many more remarkable discoveries will in course of time be due to the prism. Already, within the past twenty years, four new metals have by its aid been separated from the substances with which they were before confounded; and although they have not at present any commercial value, we may feel sure that they have been created for some good purpose not yet revealed to us. There are signs that the spectroscope will some day become a recognized adjunct to our educational appliances. It is even now included under the head of Chemistry in the examination of candidates for university honors, and there is no doubt that it will gradually have a more extended use. Many years hence, when generations of School-Boards have banished ignorance from the land, the spectroscope may become a common toy in the hands of children, enabling them to lisp:

> Twinkle, twinkle, little star;
> We know exactly what you are.

—*Chambers' Journal.*

SCIENTIFIC JOTTINGS.

Protoxide of silver has been found to be one of a remarkable class of bodies, whose action is in opposition to all recognized theories. It is stated by MM. Trooste and Hauteville that it is capable of being produced at a temperature *above* that which decomposes it. Protochloride of platinum is placed by them in the same category.

Further particulars are now available of the action of light upon the Elœococca oil. Elœmargaric acid is extracted from it by treatment with an alcoholic solution of potash, which yields a well crystallized salt, from which may be extracted the acid, melting at a temperature of 48°. Solutions of this substance in ether or bisulphide of carbon remain unchanged for an indefinite time if kept in the dark; but when exposed to light the acid is modified, so that when the solvent is removed by distillation in a current of hydrogen the residue melts at 71°. An alcoholic solution of the acid, when exposed to light, deposits fine crystals, which have the same composition as the original acid.

To the list of substances acted upon by light may be added santonine—an alcoholic solution of which was decomposed in direct sunlight with the production of an amorphous resinous mass, formic acid, and a special crystalline compound, a salt of photosantonic acid. This acid is likewise produced when a glacial acetic acid solution of santonine is exposed to light.

Iodide of potassium also has been proved to be acted upon by light. M. Battendier (*Journal Pharm. Chim.*) having stated that light quickly changes the iodide, turning it a yellow color, and liberating iodine, M. Vidan stated that the intermediation of air is not at all necessary, as was supposed. M. Battendier therefore exposed solutions of iodide of potassium—first to sunlight and air, secondly to sunlight in a vacuum, and thirdly to air in the shade—and found that in the first case only did decomposition result, from which is to be gathered, that air is necessary for the action to take place. He exposed other quantities of the solution to a variety of different actions, with and without sunlight and air. When an atmosphere of carbonic acid surrounded it decomposition took place in a couple of hours, a decided yellow color being produced in the solution. His first conclusions are that sunlight and the acids of the air, more especially the carbonic acid, are the principal causes of the change.

M. G. Planté has pointed out a new method of producing a light by the aid of electricity. On causing one of the poles of a secondary battery to touch the sides of a glass or porcelain vessel containing a saline solution, he was struck with the brilliant luminous effect produced. Pure silica, in the shape of crystals of hyaline quartz, were used with good results, greater battery power, however, being required with them than for glass. The luminous effects are put down to incandescence of the silicium.

An interesting experiment, showing the composition of white light, is communicated to a scientific contemporary by Mr. W. Terrill. Using magic lanterns and colored glasses he has been able, with two lanterns only—respectively containing blue and deep orange glass slides—to combine the lights into white by projecting the two colored disks on to one spot. With a large number of lanterns he used a greater variety of colors. The effect of only partially overlapping the two disks is very striking, the pale blue and deep orange colored edges having a remarkable and extraordinary effect upon the mind.

M. Chevreul, at the Academy of Sciences, read, a little time since, a paper bearing upon this subject, or, more particularly, *On a Phenomenon of Insolation of the Eye.* He gave an account in his paper of two noblemen playing dice (a few days before St. Bartholomew's day) who twice saw blood spots upon them, which so alarmed them that they separated and gave up the play. M. Chevreul explains the occurrence as an effect of contrast of color in sunlight, and gave some further experiments in illustration.

In giving extracts from the list of telescopes in use throughout the globe, Mr. Rutherford's refractor, which is specially

arranged for photography, is noted; it is stated to be of 10·5 Paris inches in diameter.

A paper has been presented to the Royal Society, by M. Bischof, describing a number of experiments made with his "spongy iron filter." The results were very interesting, and showed the filter to possess a very important action over certain classes of impurities to be found in water.

We may note an observation of extreme interest to photographers made by Mr. W. Crookes, at a meeting of the Physical Society. He stated that glass, though placed in a vacuum for weeks, would still retain upon its surface hygroscopic moisture, which could only be removed by heating. The usefulness of this knowledge in the preparation of glass plates may be found to be very great, as the number of pictures spoiled through being badly cleaned might be traced to some such cause.

A barometer is of untold value to the photographer, and something of this kind in a novel form is to be obtained at the present time in Paris. Artificial flowers, termed "barometers," are exhibited in a number of Parisian shops. They are colored with a material composed of chloride of cobalt, and when exposed to sun or dry air the leaves become deep blue; when the air is full of moisture they become pinky, and all intermediate shades are readily perceived. Though this little toy possesses none of the characters of a barometer—being, in fact, merely a hygrometer—it may still be of use to those who study the probabilities of weather.—*British Journal of Photography.*

HOW TO DRAW A STRAIGHT LINE.*

I must now indulge in a little simple geometry. It is absolutely necessary that I should do so in order that you may understand the principle of our apparatus.

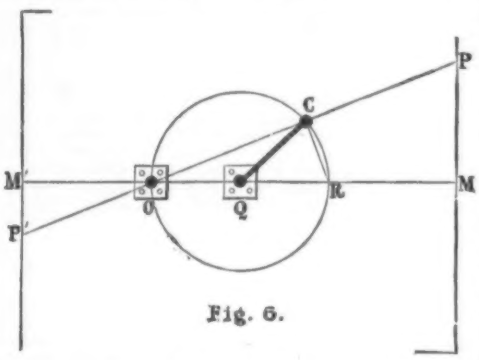


Fig. 6.

In Fig. 6, Q C is the extra link pivoted to the fixed point Q, the other pivot on it C, describing the circle O C R. The straight lines P M and P' M' are supposed to be perpendicular to M R Q O M'.

Now the angle O C R, being the angle in a semicircle, is a right angle. Therefore the triangles O C R, O M P, are similar. Therefore,

$$O C : O R :: O M : O P.$$

Therefore,

$$O C \cdot O P = O M \cdot O R,$$

wherever C may be on the circle. That is, since O M and O R are both constant, if while C moves in a circle P moves so that O, C, P are always in the same straight line, and so that O C · O P is always constant; then P will describe the straight line P M perpendicular to the line O Q.

It is also clear that if we take the point P' on the other side of O, and if O C · O P' is constant, P' will describe the straight line P' M'. This will be seen presently to be important.

Now, turning to Fig. 7, which is a skeleton drawing of the Peaucellier cell, we see that from the symmetry of the construction of the cell, O, C, P, all lie in the same straight line, and if the straight line A n be drawn perpendicular to C P—it must still be an imaginary one, as we have not yet proved that our apparatus does draw a straight line—C n is equal to n P.

Now,

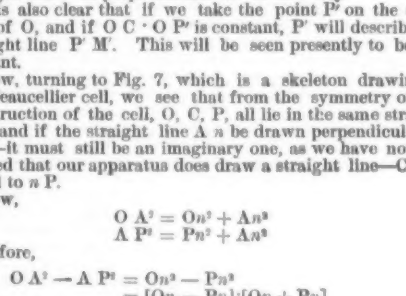
$$O A^2 = On^2 + An^2$$
$$A P^2 = Pn^2 + An^2$$

therefore,

$$O A^2 - A P^2 = On^2 - Pn^2 = [On - Pn] \cdot [On + Pn] = O C \cdot O P.$$

Thus, since O A and A P are both constant O C · O P is always constant, however far or near C and P may be to O.

Fig. 7.



If then the pivot O be fixed to the point O in Fig. 6, and the pivot C be made to describe the circle in the figure by being pivoted to the end of the extra link, the pivot P will satisfy all the conditions necessary to make it move in a straight line, and if a pencil be fixed at P it will draw a straight line. The distance of the line from the fixed pivots will of course depend on the magnitude of the quantity $O A^2 - O P^2$, which may be varied at pleasure.

I hope you clearly understand the two elements composing the apparatus, the extra link and the cell, and the part each plays, as I now wish to describe to you some modifications of the cell. The extra link will remain the same as before, and it is only the cell which will undergo alteration.

If I take the two linkages in Fig. 8, which are known as the kite and the spearhead, and place one on the other so that the long links of the one coincide with those of the other, and then amalgamate the coincident long links together, we shall get the original cell of Figs. 5 and 7. If then we keep the angles between the long links, or that between the short links, the same in the kite and spear-head, we see that the height of the kite multiplied by that of the spear-head is constant.

Let us now, instead of amalgamating the long links of the two linkages, amalgamate the short ones. We then get the linkage of Fig. 9; and if the pivot where the short links meet is fixed, and one of the other free pivots be made to

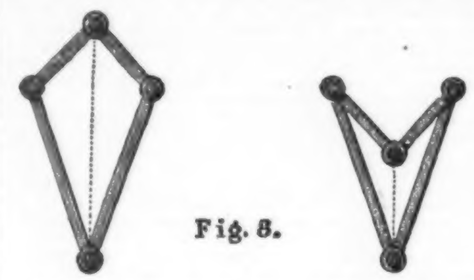


Fig. 8.

move in the circle of Fig. 6 by the extra link, the other will describe, not the straight line P M, but the straight line P' M'. In this form, which is a very compact one, the motion has been applied in a beautiful manner to the air engines which are employed to ventilate the Houses of Parliament.

The ease of working and absence of friction and noise is very remarkable. The engines were constructed and the Peaucellier apparatus adapted to them by Mr. Prim, the engineer to the Houses, by whose courtesy I have been enabled to see them, and I can assure you that they are well worth a visit.

Another modification of the cell is shown in Fig. 10. Instead of employing a kite and spear-head of the same dimensions, I take the same kite as before, but use a spear-head of half the size of the former one, the angles being, however,

FIG. 9.

kept the same, the product of the heights of the two figures will be half what it was before, but still constant. Now, instead of superimposing the links of one figure on the other, it will be seen that in Fig. 10 I fasten the shorter links of each figure together end to end. Then, as in the former cases, if I fix the pivot at the point where the links are fixed together, I get a cell which may be used, by the employment of an extra link, to describe a straight line.

A model employing this form of cell is exhibited in the Loan Collection by the Conservatoire des Arts et Métiers of Paris, and is of exquisite workmanship; the pencil seems to swim along the straight line.

M. Peaucellier's discovery was introduced into England by Prof. Sylvester in a lecture he delivered at the Royal In-

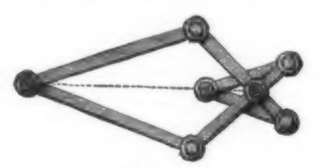


Fig. 10.

stitution in January, 1874, which excited very great interest and was the commencement of the consideration of the subject of linkages in this country.

In August of the same year, Mr. Hart, of Woolwich Academy, read a paper at the British Association meeting, in which he showed that M. Peaucellier's cell could be replaced by an apparatus containing only four links instead of six. The new linkage is arrived at thus:

If to the ordinary Peaucellier cell I add two fresh links of the same length as the long ones, I get the double, or rather quadruple cell, for it may be used in four different ways, shown in Fig. 11. Now Mr. Hart found that if he took an ordinary parallelogrammatic linkwork in which the adjacent sides are unequal, and crossed the links so as to form what is called a contra-parallelogram, Fig. 12, and then took four

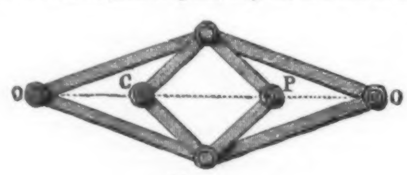


FIG. 11.

points on the four links dividing the distances between the pivots in the same proportion, those four points had exactly the same properties as the four points of the double cell. That the four points always lie in a straight line is seen thus:

Considering the triangle $a\,b\,d$, since a O: O b : : a P: P d, therefore O P is parallel to $b\,d$ and the perpendicular distance between the parallels is to the height of the triangle $a\,b\,d$ as O b is to $a\,b$; the same reasoning applies to the straight line C O', and since ab: O b : : cd: O' d and the heights of the triangles $a\,b\,d$, $c\,b\,d$, are clearly the same, therefore the distances of O P and O' C from $b\,d$ are the same, and O C P O' lie in the same straight line.

That the product O C · O P is constant appears at once when it is seen that O b C is half a spear-head, and O a P half a kite; similarly it may be shown that O' P · O' C is constant, as also O C · C O' and O P · P O'. Employing then the Hart's cell as we employed Peaucellier's, we get a five-link straight line motion. A model of this is exhibited in the Loan Collection by M. Breguet.

I now wish to call your attention to an extension of Mr. Hart's apparatus, which was discovered simultaneously by Professor Sylvester and myself. In Mr. Hart's apparatus we were only concerned with bars and points on those bars, but in the apparatus I wish to bring before you we have pieces instead of bars. I think it will be more interesting if I lead up to this apparatus by detailing to you its history, especially as I shall thereby be enabled to bring before you another very elegant and very important linkage—the discovery of Professor Sylvester.

When considering the problem presented by the ordinary three-bar motion, consisting of two radial bars and a trav-

Fig. 12.

ersing bar, it occurred to me—I do not know how or why, it is often very difficult to go back and find whence one's ideas originate—to consider the relation between the curves described by the points on the traversing bar in any given three-bar motion, and those described by the points on a similar three-bar motion, but in which the traversing bar and one of the radial bars had been made to change places. The proposition was no sooner stated than the solution became obvious; the curves were precisely similar.

In Fig. 13 let C D and B A be the two radial bars turning about the fixed centers C and B, and let D A be the traversing bar, and let P be any point on it describing a curve depending on the lengths of A B, B C, C D, and D A. Now add to the three-bar motion the bars C E and E A P', C E being equal to D A, and E A equal to C D. C D A E is then a parallelogram, and if an imaginary line C P P' be drawn, cutting E A produced in P', it will at once be seen that P' is a fixed point on E A produced, and C P' bears always a fixed proportion to C P, viz., C D: C E. Thus the curve described by P' is precisely the same as that described by P, only it is larger in the proportion C E: C D. Thus, if we take away the bars C D and D A, we shall get a three-bar linkwork, describing precisely the same curves, only of different magnitude, as our first three-bar motion described, and this new three-bar linkwork is the same as

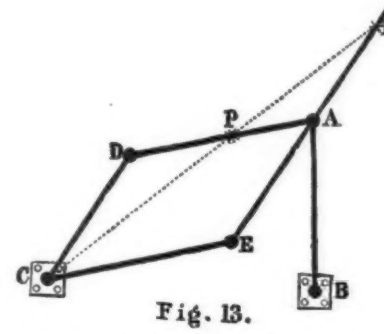


Fig. 13.

the old with the radial link C D and the traversing link D A interchanged.

On my communicating this result to Professor Sylvester, he at once saw that the property was not one confined to the particular case of points lying on the traversing bar—in fact, to three-bar motion—but was possessed by three-piece motion.

In Fig. 14, C D A B is a three-bar motion, as in Fig. 13, but the tracing point or "graph" does not lie on the line joining the joints A D, but is anywhere else on a "piece" on which the joints A D lie. Now, as before, add the bar C E, C E being equal to A D, and the piece A E P', making A E equal to C D, and the triangle A E P' similar to the triangle P D A; so that the angles A E P', A D P are equal, and

$$P' E : E A :: A D : D P.$$

It follows easily from this—you can work it out for yourselves without difficulty—that the ratio P' C: P C is constant and the angle P C P' is constant; thus the paths of P and P', or the "grams" described by the "graphs," P and

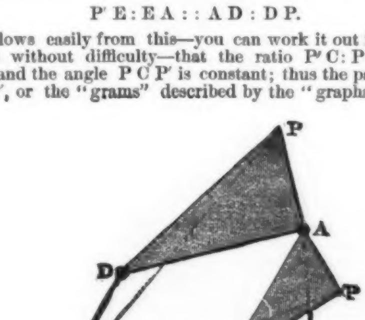


FIG. 14.

P' are similar, only they are of different sizes, and one is turned through an angle with respect to the other.

Now you will observe that the two proofs I have given are quite independent of the bar A B, which only affects the particular curve described by P and P'. If we get rid of A B, in both cases we shall get in the first figure the ordinary pantagraph, and in the second a beautiful extension of it, called by Professor Sylvester, its inventor, the Plagiograph or Skew Pantagraph. Like the pantagraph, it will enlarge or reduce figures, but it will do more; it will turn them through any required angle, for by properly choosing the position of P and P', the ratio of C P to C P' can be made what we please, and also the angle P C P' can be made to have any required value.

If the angle P C P' is made equal to 0 or 180°, we get the two forms of the pantagraph now in common use; if it be made to assume successively any value which is a sub-multiple of 360°, we can, by passing the point P each time over the same pattern, make the point P' reproduce it round the fixed center C after the fashion of a kaleidoscope. I think

* Lecture at South Kensington in connection with the Loan Collection of Scientific Apparatus, by A. B. Kempe, B.A. Continued from p. 1340.

you will see from this that the instrument, which has, as far as I know, never been practically constructed, deserves to be put into the hands of the designer.

I give here a picture of a little model of a possible form for the instrument furnished by me to the Loan Collection by request of Professor Sylvester.

After this discovery of Professor Sylvester, it occurred to him and to me simultaneously—our letters announcing our discovery to each other crossing in the post—that the principle of the plagiograph might be extended to Mr. Hart's contra-parallelogram; and this discovery I shall now proceed to explain to you. I shall, however, be more easily able to do so by approaching it in a different manner to that in which I did when I discovered it.

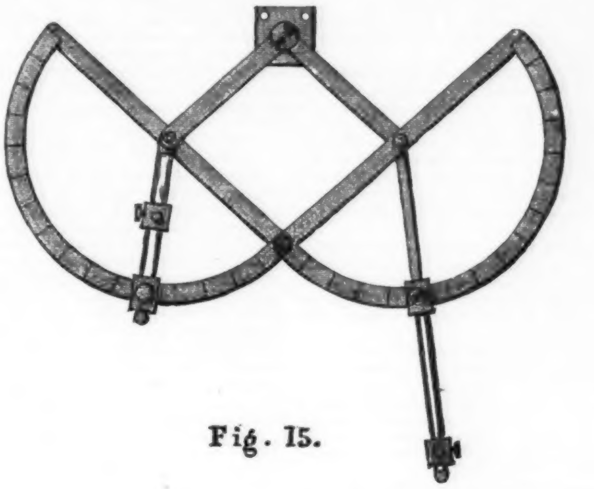


Fig. 15.

If we take the contra-parallelogram of Mr. Hart and bend the links at the four points which lie on the same straight line, or *foci*, as they are sometimes termed, through the same angle, the four points, instead of lying in the same straight line, will lie at the four angular points of a parallelogram of constant angles—two the angle that the bars are bent through, and the other two their supplements—and of constant area, so that the product of two adjacent sides is constant.

In Fig. 16 the lettering is preserved as in Fig. 12, so that the way in which the apparatus is formed may be at once seen. The holes are taken in the middle of the links, and the bending is through a right angle. The four holes O P O' C lie at the four corners of a right-angled parallelogram, and the product of any two adjacent sides, as for example O C · O P, is constant.

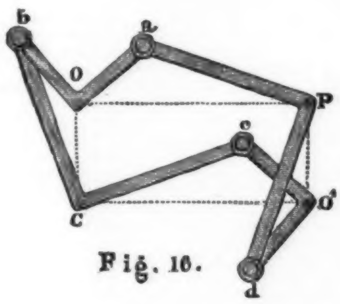


Fig. 16.

It follows that if O be pivoted to the fixed point O in Fig. 16, and C be pivoted to the extremity of the extra link, P will describe a straight line, not P M, but one inclined to P M at an angle the same as the bars are bent through, *i. e.*, a right angle. Thus the straight line will be parallel to the line joining the fixed pivots O and Q.

This apparatus, which for simplicity I have described as formed of four straight links which are afterwards bent, is of course, strictly speaking, formed of four plane links, such as those employed in Fig. 1, on which the various points are taken. This explains the name given to it by Professor Sylvester, the "Quadruplane." Its properties are not difficult to investigate, and when I point out to you that in Fig. 16, as in Fig. 12, O *b*, *b* C form half a "spear-head," and O *a*, *a* P half a "kite," you will very soon get to the bottom of it.

I cannot leave this apparatus in which my name is associated with that of Professor Sylvester without expressing my deep gratitude for the kind interest which he took in my researches, and my regret that his departure for America to undertake the post of Professor in the new Johns Hopkins University has deprived me of one whose valuable suggestions and encouragement helped me much in my investigations.

CHRONOMETER TRIALS AT GENEVA, 1876–77.

Professor Plantamour reports:

This year's competitive trials have again given very good results. The following were the conditions imposed, and which were not quite so rigorous as those of last year:

1. Mean daily rate, not to exceed 1 second per day.
2. Variation in six positions, not to exceed 3 seconds during the 7 days' trial.
3. Error in compensation produced by differences in temperature, not to exceed 0·33 second per degree.

A special prize was offered for a collection of 6 chronometers belonging to the same firm, and giving the best mean results. Out of 63 chronometers, 41 underwent the required tests successfully. This proportion of 41 to 63, that is about two thirds, is the usual one. So at the international trials of last year, out of 82 chronometers submitted, 55 fulfilled the conditions of the trials.

These 41 chronometers were supplied by 12 different firms—the well known houses of H. R. Ekegren, Alexis Favre, Patek, Philippe & Cie., being represented by 6, 7, and 10 chronometers respectively.

If we take the mean variation of these 41 chronometers, for each of the three tests, we obtain very satisfactory figures.

The mean variation for the 1st trial was ± 0s,499.
For 4 chronometers, 0s,25; 0s,25; 0s,26; 0s,27.
For the 2d trial ± 1s,672.
In 4 chronometers, 0s,33; 0s,50; 0s,77; 0s,88.
For the 3rd trial ± 0s,104.

For 3 chronometers the error in compensation was *nil*, or at least under half a hundredth of a second per degree.

Last year's figures were:

For the 1st trial ± 0s,544.
For the 2d trial ± 1s,08.
For the 3d trial ± 0s,123.

H. R. Ekegren was the most successful competitor; the 6 chronometers submitted by him gave a mean variation of ± 0s,455; 1s,033; 0s,087 for the 1st, 2d, and 3rd trials respectively, the special prize for the 6 best chronometers was therefore awarded to him.

ON VORTEX MOTION.

By Professor Osborne Reynolds, Owens College, Manchester.*

In commencing this discourse the author said, Whatever interest or significance the facts of vortex motion may have is in no small degree owing to their having, as it were, eluded the close mathematical search which has been made for them, and to their having in the end been discovered in a simple, not to say commonplace, manner. In the Royal Institution it is the custom to set forth the latest triumphs of mind over matter, the secrets last wrested from nature by gigantic efforts of reason, imagination, and the most skillful manipulation. For once, however, it would seem that the case is reversed, and that the triumph rests with nature, in having for so long concealed what has been so eagerly sought, and what is at last found to have been so thinly covered.

The various motions which may be caused in a homogeneous fluid like water, present one of the most tempting fields for mathematical research. For not only are the conditions of the simplest, but the student or philosopher has on all hands the object of his research, which, whether in the form of the Atlantic waves or of the eddies in his teacup, constantly claims his attention. And, besides this, the exigencies of our existence render a knowledge of these motions of the greatest value to us in overcoming the limitations to which our actions are otherwise subject.

Accordingly we find that the study of fluid motion formed one of the very earliest branches of philosophy, and has ever since held its place, no subject having occupied the attention of mathematicians more closely. The results have been, in one sense, very successful; most important methods of reasoning have been developed—mathematical methods, which have helped to reveal numberless truths in other departments of science, and have taught us many things about fluids which most certainly we should not otherwise have found out, and of which we may some day find the application. But as regards the direct object in view, the revelation of the actual motion of fluids, the research has completely failed. And now that generations of mathematicians have passed away, now that the mysteries of the motions of heavenly bodies, of the earth itself, and almost of every piece of solid matter on the earth have been explained by mathematicians, the simplest problems of fluid motion are yet unsolved.

If we draw a disc flatwise through the water, we know by a process of unconscious geometrical reasoning that the water must move around the disc; but by no known mathematical process could the motion be ascertained from the laws of motion. If we draw the plate obliquely through the water we experience a greater pressure on the one side than on the other. Now this case, representing as it does the principle of action of the screw propeller, is of the very highest importance to us; and yet, great as has been the research, it has revealed no law by which we may in a given case calculate the resistance to be obtained, or indeed tell from elementary principles in what way the water moves to let the plate pass. Again the determination of the resistance which solid bodies, such as ships, encounter is of such exceeding economic importance that theory, as shipbuilders call it, having failed to inform them what to expect, efforts have been, and are still being made to ascertain the laws by direct experiment. Instances might be multiplied, but one other must suffice. If we send a puff of fluid into other fluid we know that it will travel a considerable distance; but the manner in which it will travel and the motion it will cause in the surrounding fluid, mathematics have not revealed to us.

Now the reasons why mathematicians have been thus baffled by the internal motions of fluids appear to be very simple. Of the internal motions of water or air we can see nothing. On drawing the disc through the water there is no evidence of the water being in motion at all, so that those who have tried to explain these results have had no clue; they have had not only to determine the degree and direction of the motion, but also its character.

But although the want of a clue to the character of the motion may explain why so little has been done, it is not so easy to understand how it is that no attempts were made to obtain such a clue. It would seem that a certain pride in mathematics has prevented those engaged in these investigations from availing themselves of methods which might reflect on the infallibility of reason.

Suggestions as to the means have been plentiful. In other cases where it has been necessary to trace a particular portion of matter in its wanderings amongst other exactly similar portions, ways have been found to do it. It may be argued that the influences which determine the path of a particular portion of water are slight, subtle, and uncertain, but not so much so as those which determine the path of a sheep. And yet thousands of sheep belonging to different owners have been from time immemorial turned loose on the mountains, and although it probably never occurred to any-one to reason out the paths of his particular sheep, they have been easily identified by the aid of a little color. And that the same plan might be pursued with fluids, every column of smoke has been evidence.

But these hints appear to have been entirely neglected, and it was left for nature herself, when, as it were, fully satisfied with having maintained her secret so long, and tired of throwing out hints which were not taken, at last to divulge the secret completely in the beautiful phenomenon of the smoke ring. At last; for the smoke ring is probably a phenomenon of modern times. The curls of smoke, as they ascend in an open space, present to the eye a hopeless entanglement; and although, when we know what to look for, we can see as it were imperfect rings in almost every smoke cloud, it is rarely that anything sufficiently definite is formed to attract attention, or suggest anything more important than an accidental curl. The accidental rings, when they are formed in a systematic manner, come either from the mouth of a gun, the puff of a steam engine, or the mouth of a smoker, none of which circumstances existed in ancient times.

Although, however, mathematicians can in no sense be said to have discovered the smoke ring, or the form of motion which it reveals, they are undoubtedly the first to invest it with importance. Had not Professor Helmholtz some twenty years ago called attention to the smoke ring by the beautiful mathematical explanation which he gave of its motion, it would in all probability still be regarded as a casual phenomenon, chiefly interesting from its beauty and rarity. Following close on Helmholtz came Sir William Thomson, who invested these rings with a transcendental interest by his suggestion that they are the type after which the molecules of solid matter are constituted.

The next thing to enhance the interest which these rings excited was Professor Tait's simple and perfect method* of producing them at will, and thus rendering them subjects for lecture room experiments. Considering that this method will probably play a great part in perfecting our notions of fluid motion, it is an interesting question how Professor Tait came to hit upon it. There is only one of the accidental sources of these rings which bears even a faint resemblance to this box, and that is the mouth of a smoker as he produces these rings. This might have suggested the box to Professor Tait. But since this supposition involves the assumption that Professor Tait sometimes indulges in a bad habit, and as we all know that Professor Tait is an eminent mathematician, perhaps we ought rather to suppose that he was led to his discovery by some occult process of reasoning which his modesty has hitherto kept him from propounding.

But however this may be, his discovery was a most important one, and by its means the study of the actual motion of these rings has been carried far beyond what would otherwise have been possible.

But it has been for their own sake, and for such light as they might throw on the constitution of matter, that these rings were studied. The most important lesson which they were capable of teaching still remained unlearned. It does not appear to have occurred to anyone that they were evidence of a general form of fluid motion, or that the means by which these had been revealed would reveal other forms of motion.

There was, however, at least one exception, which will not be forgotten in this room: the use of smoke to show the effect of sound upon jets of air.

Also, the late Mr. Henry Deacon, in 1871, showed that minute vortex rings might be produced in water by projecting a drop of colored water from a small tube. And his experiments, in spite of their small scale, excited considerable interest.

Four years ago, being engaged in investigating the action of the screw propeller, and being very much struck by the difference between some of the results he obtained and what he had been led to expect, the author made use of color to try and explain the anomalies, when he found that the vortex played a part in fluid motion which he had never dreamt of; that, in fact, it was the key to almost all the problems of internal fluid motion. That these results were equally new to those who had considered the subject much more deeply than he had, did not occur to him until after some conversation with Mr. Froude and Sir William Thomson.

Having noticed that the action of the screw propeller was greatly affected when air was allowed to descend to the blades, he was trying what influence air would have on the action of a simple oblique vane, when a very singular phenomenon presented itself. The air, instead of rising in bubbles to the surface, ranged itself in two long horizontal columns behind the vane. There was evidence of rotational motion about these air lines. It was evident, in fact, that they were the central lines of two systematic eddies.

That there should be eddies was not surprising, but eddies had always been looked upon as necessary evils which beset fluid motion as sources of disturbance, whereas here they appeared to be the very means of systematic motion.

Here then was the explanation of the nature of the motion caused by the oblique vane, a cylindrical band of vortices continually produced at the front of the plate, and falling away behind it in an oblique direction.

The recognition of the vortex action caused behind the oblique vane suggested that there might be similar vortices behind a disc moving flatwise through the water, such as are the eddies caused by a teaspoon.

* A lecture delivered at the Royal Institution.

* The apparatus consists of a cubical box like a tea chest, with a circular hole, six or eight inches in diameter, in its bottom, and a cloth loosely nailed over the top in place of a lid. The box is set on its end. The fumes of hydrochloric acid and ammonia are separately introduced into the box, when they combine and form a dense smoke, which is ejected from the orifice by patting the cloth. It appears that a somewhat similar form of apparatus was used by Faraday, and has long been known as a toy.—O. R.

There was one consideration, however, which at first seemed to render this improbable. It was obvious that the resistance of the oblique vane was caused in producing the vortices at its forward part; so that if a vortex were formed behind a flat plate, as this vortex would remain permanently behind, and not have to be continually elongated, the resistance should diminish after the plate was once set in motion; whereas experience appeared to show that this was by no means the case. It appeared probable, therefore, that from some disturbing cause the vortex would not form, or would only form imperfectly, behind the plate.

This view was strengthened when, on trying the resistance of a flat plate, it did not appear to diminish after the plate had been started.

Accidentally, however, it was found that if the float to which the plate was attached was started suddenly and then released, the float and plate would move on apparently without any resistance. And more than this, for if the float were suddenly arrested and released, it would take up its motion again, showing that it was the water behind that was carrying it on.

There was evidence, therefore, of a vortex behind the disc. In the hope of rendering this motion visible, colored water was injected in the neighborhood of the disc, and then a beautiful vortex ring, exactly resembling the smoke ring, was seen to form behind the disc. If the float were released in time, this ring would carry the disc on with it; but if the speed of the disc were maintained uniform, the ring gradually dropped behind and broke up. Here then was another part played by the vortex previously undreamt of.

That the vortex takes a systematic part in almost every form of fluid motion was now evident. Any irregular solid moving through the water must from its angles send off lines of vortices such as those behind the oblique vane. As we move about we must be continually causing vortex rings and vortex bands in the air. Most of these will probably be irregular, and resemble more the curls in a smoke cloud than systematic rings. But from our mouths as we talk we must produce numberless rings.

One way in which rings are produced in perhaps as great numbers as from our mouths is by drops falling into the sea. If we color the surface of a glass vessel full of water, and then let drops fall into it, rings are produced, which descend sometimes as much as two or three feet.

But the most striking rings are those produced in water, in a manner similar to that in which the smoke rings are produced, using colored water instead of smoky air.

These rings are much more definite than smoke rings, and although they cannot move with higher velocities, since that of the smoke ring is unlimited, the speed at which they move is much more surprising.

In the air we are accustomed to see objects in rapid motion, and so far as our own notions are concerned, we are unaware of any resistance; but it is quite otherwise in water. Every swimmer knows what resistance water offers to his motions, so that when we see these rings flash through the water we cannot but be surprised. Yet a still more striking spectacle may be shown, if, instead of colored water, a few bubbles of air be injected into the box from which the puff is sent; a beautiful ring of air is seen to shoot along through the water, showing, like the lines of air behind the oblique vane, little or no tendency to rise to the surface.

Such is the case with which these vortex rings in water move, and so slight is the disturbance which they cause in the water behind them, as to lead to the conclusion that they experience no resistance whatever, except perhaps a little caused by slight irregularities in their construction. Their velocity gradually diminishes; but this would appear to be accounted for by their growth in size, for they are thus continually taking up fresh water into their constitution, with which they have to share their velocity. Careful experiments have confirmed this view. It is found that the force of the blow they will strike is nearly independent of the distance of the object struck from the orifice.

The discovery of the ring behind the disc afforded the opportunity of observing the characteristics of these rings much better than those afforded by the smoke rings; and also suggested facts which had previously been overlooked. The manner of motion of the water which formed the ring and of the surrounding water was very clearly seen. It was at once seen that the visible ring, whether of colored water or air, was merely the central line of the vortex; that it was surrounded by a mass of moving water, bearing somewhat the same proportion to the visible ring as a ball made by wrapping string (in and out) round a curtain ring until the aperture was entirely filled up. The disc, when it was there, formed the front of this ball or spheroid of water, but the rest of the surface of the ball had nothing to separate it from the surrounding water but its own integrity. Yet when the motion was very steady the surface of the ball was definite, and the entire moving mass might be rendered visible by color. The water within the ball was everywhere gyrating round the central ring, as if the coils of string were each spinning round the curtain ring as an axis, the water moving forwards through the interior of the ring and backwards round the outside, the velocity of gyration gradually diminishing as the distance from the central ring is increased.

The way in which the water moves to let the ball pass can also be seen, either by streaking the water with color or suspending small balls in it. In moving to get out of the way and let the ball of water pass, the surrounding water partakes as it were of the gyrating motion of the water within the *ball*, the particles moving in a horse-shoe fashion, so that, at the actual surface of the *ball*, the motion of the water outside is identical with that within, and there is no rubbing at the surface, and consequently no friction.

The maintenance of the shape of the moving mass of water against the unequal pressure of the surrounding water as it is pushed out of the way is what renders the internal gyratory motion essential to a mass of fluid moving through a fluid. The centrifugal force of this gyratory motion is what balances the excess of pressure of the surrounding water in the front and rear of the ball, compared with what it is at the sides.

It is impossible to have a ring in which the gyratory motion is great, and the velocity of progression slow. As the one motion dies out so does the other; and any attempt to accelerate the velocity of the ring, by urging forward the disc, invariably destroyed it.

The striking case with which the vortex ring, or the disc with the vortex ring behind it, moves through the water, naturally raised the question as to why a solid should experience resistance. Could it be that there was something in the particular spheroidal shape of these balls of water which allowed them to move freely? To try this, a solid of the same shape as the fluid ball was constructed and floated after the same manner as the disc. But when this was set in motion, it stopped directly—it would not move at all. What was the cause of this resistance? Here were two objects of the same shape and weight, the one of which moved freely through the water, and the other experienced very great resistance. The only difference was in the nature of the surface. As already explained, there is no friction at the surface of the water, whereas there must be friction between the water and the solid. But it could be easily shown that the resistance of the solid is much greater than what is accounted for by its surface friction or skin resistance. The only other respect in which these two surfaces differ is that the one is flexible while the other is rigid, and this seems to be the cause of the difference in resistance.

If ribbons be attached to the edge of the disc, these ribbons will envelope the ball of water which follows it, presenting a surface which may be much greater than that of the solid; and yet, this being a flexible surface, the resistance of the disc with the vortex behind it is not very much greater than it would be without the ribbons—nothing to be compared to that of the solid.

Coloring the water behind the solid shows that, instead of passing through the water without disturbing it, there is very great disturbance in its wake. An interesting question is as to whether this disturbance originates with the motion of the solid, or only after the solid is in motion. This is settled by coloring the water immediately in front of the solid before it is started. Then on starting it the color is seen to spread out in a film entirely over the surface of the solid, at first without the least disturbance, but this follows almost immediately.

Among the most striking features of the vortex rings is their apparent elasticity. When disturbed they not only recover their shape, but vibrate about their mean position like an elastic solid. So much so, as to lead Sir William Thomson to the idea that the elasticity of solid matter must be due to its being composed of vortex rings.

But apart from such considerations, this vibration is interesting as showing that the only form of ring which can progress steadily is the circular. Two parallel bands, such as those which follow the oblique vane, could progress if they were infinitely long; but if not, they must be continually destroyed from the ends. Those which follow the oblique vane are continually dying out at one end, and being formed again at the other.

If an oval ring be formed behind an oval plate, the more sharply curved parts travel faster than the flatter parts; and hence, unless the plate be removed, the ring breaks up. It is possible, however, to withdraw the plate, so as to leave the oval ring, which proceeds wriggling along, each portion moving in a direction perpendicular to that in which it is curved, and with a velocity proportional to the sharpness of the curvature. So that not only does the ring continually change its shape, but one part is continually falling behind, and then overtaking the other.

These are some of the forms of fluid motion which imagination or reason had failed to show us, but which have been revealed by the simple process of coloring the water.

Now that we can see what we are about, mathematics can be most usefully applied; and it is expected that when these facts come to be considered by those best able to do so, the theory of fluid motion will be placed on the same footing as the other branches of applied mechanics.

TEMPERATURE AND ORGANIC REMAINS IN TAHOE AND ECHO LAKES.

AT a recent meeting of the California Academy of Sciences, Dr. James Blake, of Napa county, read the following:

During my stay in the vicinity of these mountain lakes, I took the opportunity of ascertaining their temperature at different depths, by means of a Casella deep sea thermometer, and also of using the two net and dredge in both lakes. Owing to the overturning of the wagon in which I was descending from the mountains, I unfortunately lost the note book containing the record of my observations, so that I can now only relate from memory the principal facts observed. As regards the temperature, I found the surface water of Lake Tahoe at the temperature of 62°. This was in the middle of July, at a time when the temperature of the air was ranging from 36° to 76°. Near the south shore the temperature of the water would rise 4° or 5° during the hotter part of the day, but would be again 62° at sunrise, although the air was 36°. This high temperature was found only in the shallower water at the south end of the lake, where the depth for half a mile from the shore gradually increases to about 16) feet. Beyond the edge of this bank the depth suddenly increases so that the next sounding, at not more than 300 yards from the edge of the bank, gave a depth of 500 feet, with a bottom temperature of 39.7°; the temperature at the surface being 62°. Owing to the sounding machine getting out of order, I was unable to ascertain the temperature at greater depths, but as 39.4° is the temperature at which water attains its greatest density, it is probable that no lower temperature would be found even at the deepest part of the lake.

In Echo lake, which is at an elevation of 1,000 feet above Lake Tahoe, and about 150 feet deep in the deepest part, the temperature of the water at the bottom at a depth of 145 feet was 41.3°. This was in the month of July, at a time when snow was still found in spots at a few feet from the shores of the lake. The surface temperature was from 56° to 62°, the temperature of air ranging from 30° to 70°. At the time the soundings were taken the temperature of the water at the surface was 62°, of the air 68°.

In using the tow net I found, both in Lake Tahoe and in Echo lake, the surface of the water swarming with cirripeds, although the number in Lake Tahoe far exceeded that in Echo lake. The net when towed near the surface only contained the perfect insect, but at a depth of 20 ft. from the surface nothing but the ova in different phases of development were obtained, and not a perfect insect. This fact probably explains the absence of these insects in running water, as it would seem that the ova only meet with the conditions favorable for their development in water where they can remain at a depth from the surface, a condition that cannot be secured in running water. Owing to an accident I met with shortly after my return from the mountains, the objects collected from the dredge were not examined and have since been mislaid.

At the depth of 500 feet I found the bottom of Lake Tahoe covered with the same deposit of disintegrated granite which is found so extensively at the south end of the valley and at other points on the shores of the lake. The larger part of the bed of the lake is formed probably of the same material, and not, as in Echo lakes, of a hard, rocky bottom, although at many points near the shore the bottom can be seen to be formed by boulders. There is, however, this difference between the two lakes, that whilst the basins of Echo lakes were evidently ground out by ice action, Lake Tahoe for ages before the ice epoch had been the receptacle of the washings from the mountain masses that surround it, and during the ice period I believe glaciers had little to do in modifying it. Even as regards Emerald bay and Fallen Leaf lake, I cannot agree with Prof. LeConte in considering them as formed by ice action. There can be no doubt but that the shores of these lakes are formed to a great extent of moraine matter and also the bars that separate them from the main lake, but that ice should scoop out these basins at a depth of from 1,600 to 2,000 feet beneath the surface of the water, I think very improbable. I believe both Fallen Leaf lake and Emerald bay to be deep mountain fissures, modified by ice action. I would also here correct another mistake into which Prof. LeConte seems to have fallen, by regarding these smaller lakes as the result of ice action. He observes that the scooping action of the ice is in these lakes at the upper end, whilst the glacial deposits are at the lower end. In Echo lake, which has undoubtedly been scooped out by ice action, the upper end of the lake is quite shallow and slopes off very gradually, with a perfectly smooth bottom, the greatest depth in the lake being reached at two-thirds of the distance from the upper end.

THE WORLD OF MATTER.

UNDER this head Mr. R. Hitchcock in the *Journal of Microscopy*, says:—None of us in our younger days, blowing soap bubbles with a clay tobacco pipe, and gazing at the reflections in the transparent film, ever thought that there could be any more beauty in a soap bubble than our eyes could see. But Sir William Thomson saw something more than this film of water, and he has yet by patient and delicate experiment determined the size of the ultimate molecules of water by measuring the contractile force of this bubble as it was blown thinner and thinner. We may readily follow the principles involved in these researches when we consider that as the film grows thinner the contractile force remains the same until it becomes so thin that the walls are composed of an appreciably small number of molecules, constituting its thickness. Thus the contractile force of a film one ten thousandth of a millimetre in thickness, is appreciably the same as a thicker one. If the film be now reduced to one twenty millionth of a millimetre, the contractile force will be found greatly diminished. Now, we find that the heat, equivalent to the mechanical force required to reduce the film thus far, is much greater than the amount required to convert the water into vapor, *i. e.*, to destroy the water as such. Hence we must conclude that before the film reaches the twenty millionth of a millimetre in thickness the contractile force must greatly diminish, and since such a diminution cannot take place with several molecules in the film, there cannot be several molecules in the twenty millionth of a millimetre. For fear of making the communication too long, I shall not attempt to condense the methods employed by other workers to reach this same result. Suffice to say, that the above course of experiment thus crudely condensed is only one of a number of courses, all of which demand the most careful and accurate physical experimentation, which few are sufficiently gifted to undertake.

We may feel certain that the molecules of solids and liquids must measure between the ten millionth and two hundred millionth of a millimetre in diameter. One millionth—.03937 inch. Considering the molecule to be one twenty millionth of a millimetre, the size in fraction of an inch would be about one five hundred millionth of an inch.

A good clear exposition of this subject, by Prof. G. F. Barker, of Philadelphia, may be found in the *American Chemist* for last November. Such numbers are small beyond our conceptions. But we have not reached the limits of divisibility of matter. The chemist recognizes still another particle of matter, the atom, of which these molecules are composed. This atom is indivisible as far as we yet know (although the spectroscope has indicated that some of our atoms may be compounds) and has a constant size and weight.

We see, then, that the measures of the wave lengths of light are much larger than the diameter of the compound molecules of matter; in fact some 10,000 times greater. As the microscope becomes more perfect, we will no doubt be able to see much that is now perfectly invisible. But we can never even approach the study of molecules. Even now we can frequently see fine particles suspended in a liquid so minute that even the highest powers of the microscope cannot show the particles when placed on the slide. We see them as a cloudiness or turbidity in the liquid viewed in quantity and recognize their presence by the colored light reflected from them. Already, then, we have divided matter to an extent that it is invisible by the microscope, but these particles are infinitely larger than the molecules.

[NATURE.]

ASTRONOMICAL.

THE REVOLVING DOUBLE STARS.

DR. DOBERCK, of Col. Cooper's Observatory, Markree, has has published elements of ξ Bootis, calculated from measures extending over ninety-five years, which interval appears to be about two-thirds of a complete revolution. In this second computation for the same star he has followed a suggestion made in this column (*Nature*, vol. xiv., p. 475), with regard to the probable interpretation of Sir William Herschel's measures in 1792 and 1795, and the results prove the necessity for the alteration proposed.

We are now indebted to Dr. Doberck for orbits of thirteen of the revolving double stars, calculated in every case in the most complete manner possible from the available data, and which have been communicated from time to time to the Royal Irish Academy. They form collectively a very valuable contribution to this department of astronomy. Col. Cooper may be congratulated on such work emanating from his observatory, and Dr. Doberck likewise on the success which has attended his efforts. We subjoin the periods and eccentricities for Dr. Doberck's stars, omitting only ζ Aquarii, which from the great length of period is open to more uncertainty than the others:

	Period. Years.	Eccentricity.
γ Coronæ Borealis	95·5	0·350
ξ Scorpii	95·9	0·077
ω Leonis	110·8	0·536
ξ Bootis	127·4	0·708
τ Ophiuchi	185·2	0·582
η Cassiopeiæ	222·4	0·576
λ Ophiuchi	241·0	0·493
44 Bootis	261·1	0·710
μ^2 Bootis	290·1	0·617
36 Andromedæ	349·1	0·654
γ Leonis	402·6	0·739
σ Coronæ Borealis	843·2	0·750

The number of binary stars of which the orbits have been determined by various calculators, with a greater or less degree of precision, now amounts to twenty-five. The shortest period of revolution hitherto detected belongs to 42 Comæ Berenices, which, according to M. Dubiago, of Pulkowa, in a communication from M. Otto Struve to the St. Petersburg Academy in May, 1875, amounts to only 25·71 years. The star was single in 1845 and 1870–71; in 1829 and 1854–55 the distance of the components slightly exceeded six-tenths of a second, which is the greatest separation.

PHYSICAL OBSERVATIONS OF MARS.

Mr. Marth has communicated to the Royal Astronomical Society an elaborate paper intended to facilitate physical observations of the planet Mars during the favorable opposition of the present year, when it is much to be desired that observations tending to improve our knowledge of the planet may be undertaken by those who are provided with adequate instruments. Mr. Marth has calculated the areographical longitude and latitude of the center of the disc for the times of about ninety sketches of Mars, by Dawes, von Franzenau, Harkness, Kaiser, Lassell, Lockyer, Rosse, and Secchi, and with the aid of a table applicable to the interval June 9—December 14, with very little trouble the observer will be enabled to refer to the particular drawing which applies the most nearly to the time of any proposed observation, and will thereby be assisted in fixing upon the details of the surface which it may be desirable to direct his attention. The table contains the angle of position of the axis of Mars, no doubt from Bessel's elements, or rather those deduced by Oudemanns from the observation of the Königsberg astronomer, the areographical western longitude and the latitude of the center of the disc, the apparent diameter, the amount and position of the greatest defect of illumination, and the areocentric angle between the earth and sun, all quantities for Greenwich alternate noon. Vol. xxxii. of the "Memoirs of the Royal Astronomical Society" contains the sketches of Lassell, Lockyer, and Rosse, and this volume alone would be of considerable assistance to the intending observer, as will appear from Mr. Marth's second table.

MARS IN THE AUTUMN OF 1877.

By RICHARD A. PROCTOR, F.R.A.S.

THE approaching opposition is important in two chief respects. First, it affords a favorable opportunity for determining the sun's distance; and secondly, it will be possible to study under very favorable conditions the southern hemisphere of Mars.

On the first point it is not necessary to say much here. I have already entered somewhat fully into the merits of this particular method of determining the sun's distance in chapter I. of my treatise on the sun. I believe it will be found that the observations to be made next September by this method will afford measures of the sun's distance comparing favorably with those obtainable by any other methods, including the observations of Venus in transit.

The aspect which will be presented by Mars as seen in the telescope will not differ greatly at any time during the approaching opposition from that indicated in the six illustrative projections. These represent six stages of Martian rotation, separated by 60°, or by 4 hours of Martian time. On September 5 Mars comes into opposition at midnight. At this hour the Martian meridian crossing the center of the disc of Mars will be nearly in 26° east Martian longitude, or the meridian passing some 15° east of Dawes' Forked Bay in the accompanying chart. The view nearest to this in the series of six is No. 2, in which the central meridian is in 30° Martian longitude east. The rotation of Mars occurring in the direction shown by the arrow, and one degree of rotation being completed in about 4m. 6⅓s., it follows that the aspect shown in No. 2 will be presented at about 16½ minutes before midnight September 5. The observer will have no difficulty in determining when the other views may be looked for. On any the same night, the interval between one view and the next amounts to about 4h. 6m. 14s. (the rotation period of Mars being 24h. 37m. 22·7s.); and neglecting the angular motion of Mars about the earth, which in such a case we may do for short intervals of time, any view changes nearly into the *preceding* for the *same* hour of the night in the course of six nights. For, in each terrestrial day the planet completes one rotation, less the amount of rotation corresponding to 37m. 22·7s., and six times this daily loss of rotation gives the rotation corresponding to about 3h. 44m. 16s., or only 22m. short of the amount corresponding to one-sixth of a Martian day. In seven days the loss corresponds to 4h. 21m. 30s., or only about 15½m. more than the amount corresponding to one-sixth of a Martian day. Thus, neglecting his angular motion round the earth, Mars presents the aspect shown in No. 1, six days less 22m., or seven days *plus* 15½m. *after* he had presented the aspect shown in No. 2.

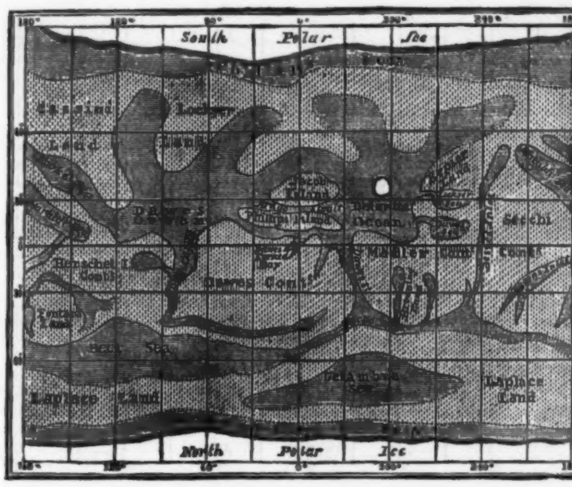
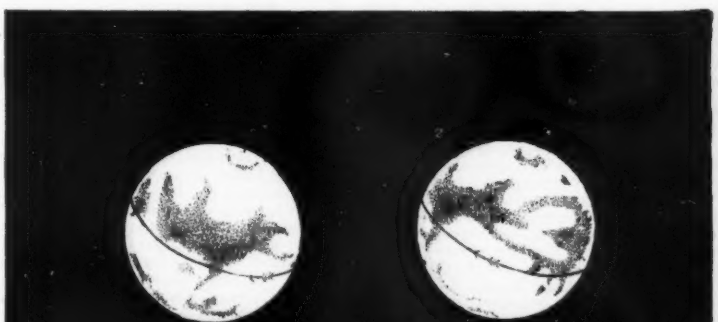


CHART OF MARS ON MERCATOR'S PROJECTION.



MARS DURING THE OPPOSITION OF 1877.

It may, however, be convenient to the observer to introduce the correction of Mars' angular motion round the earth, which, indeed, though small for the motion of Mars during six or seven days (even) when he is in opposition, necessarily becomes appreciable in the course of several weeks, during which the planet is favorably placed for observation before and after opposition. The correction can readily be made as follows: From the "Nautical Almanac" mark in the position of Mars at intervals of ten days (say) in any atlas showing longitude and latitude. (In my "School Atlas" the longitude and latitude lines are indicated by their points of intersection to every 30°; but it will be found easy to fill in, on a tracing taken from the proper map, the intermediate longitude and latitude lines to every 5° or 10°.) Thus the geocentric motion of the planet in longitude is indicated. Direct motion in geocentric longitude delays *pro tanto* the coming of a Martian meridian to the center of the disc of Mars, while retrograde motion in geocentric longitude hastens *pro tanto* the arrival of a Martian meridian at the center. For instance, suppose that on a given day soon after opposition Mars has retrograded $\alpha°$ in longitude from his opposition place on the chart, and that the epoch t is calculated for a given view of six formulas, numbered 1, 2, etc., without taking into account the change of Mars' position relatively to the earth. Then that view will be presented at the time t—(4m. 6⅓s.) α.

The above data will be sufficient for determining the aspect of the planet at any time during the approaching opposition. Account will, of course, have to be taken of the gibbosity of Mars, as affecting the apparent position of his central meridian at any time: but the "Nautical Almanac" supplies the necessary information for this purpose.

The points to which I would direct the special attention of observers are three—first, the position of the south polar snow-cap; secondly, the rotation period of the planet; and thirdly, the determination of the configuration of various lands and seas presently to be mentioned.

If on every good observing night the angle of position of the center of the snow-cap with reference to the center of the disc could be determined in the same manner as in the case of a double star—the center of the snow-cap corresponding to the companion and the center of the disc to the primary—the observations could not fail to be of value, as showing whether the snow-cap occupies the true pole, or if not, how far from the true pole its center lies, and also showing where the true south pole of the planet lies.

It remains only that I should consider what special observations of the features of Mars are now likely to be of service.

In the first place, I think the time has come for a more careful study of the varieties of light and shade and of color in this interesting planet. It should be noticed that the apparent discrepancies between many excellent drawings are probably in the main due to this cause. I have studied hundreds of views of the planets, and at first I used to be greatly perplexed by finding that two skillful observers seem to see two different planets with their telescopes. The drawings constructed by one observer agree most satisfactorily *inter se*, and so do those obtained by the other; but when one set is compared with the other the most startling discrepancies are noted. I am disposed now to attribute this chiefly to the fact that slight varieties of shade have not been sufficiently noted, or, if so, have not been adequately indicated. In the main, observers are apt to divide the surface of Mars into two tints, one light, the other, dark, and one observer will set a portion which is faintly shaded in the dark part of his picture, while the other, not recognizing the difference of shading, perhaps, or else considering it unimportant, sets that portion in the light part. As the coloring of Mars is in reality exceedingly delicate, especially in certain portions of the planet, and as, moreover, different eyes differ greatly in their estimate of color, the drawings are not corrected on this account, as otherwise we should expect. The ordinary text-book notion that the surface of Mars is divided into a ruddy portion, a green portion, and the white polar snow-caps—with perhaps occasional white cloud-markings—is altogether remote from the truth. Only a very small portion of the land has a ruddy tint which can be regarded as well defined, and though the greenish line of the seas perhaps extends a little more widely (at least for most eyes), it is wanting over large tracts usually regarded as marine in character.

As a general rule it may be considered that a dark marking

once fairly seen is to be regarded as indicating a sea-region, whether commonly seen or not. We cannot but suppose that on Mars, as on our own earth, there are sea-regions where clouds are very prevalent, and where, therefore, we are seldom likely to catch the dark hues of the sea. Our observations are after all only made under favorable conditions at long intervals; and those of the northern regions of Mars have been as yet very imperfect, because when Mars turns his north polar regions earthwards, he is near the aphelion of his orbit, or, in other words, the summer of Mars' northern hemisphere, like the summer of our own northern hemisphere, occurs near the aphelion of the orbit. This part of my chart of Mars will probably require more correction than any other part.

Great interest will attach to the study of such changes as may be produced by the formation and dissipation of clouds over the surface of Mars, or the melting of snows either with the progress of the Martian year or possibly even during the course of the Martian day. The approaching opposition occurs about a fortnight before Martian midsummer for the southern hemisphere, the date of which is about September 18. As the melting of the snows which surround the southern hemisphere will probably reduce that snow-cap to a minimum about a month later, observers will have a very favorable opportunity of studying the reduction of the southern snows. Moreover, the smallness of the snow-cap will render it easier to ascertain whether its center is coincident with the south pole, or, as is now generally believed, measurably displaced from that point. Observations directed to this end cannot but be regarded as extremely interesting. They will not only help to determine the true position of the Martian pole, but also to indicate the position of some of the midsummer isotherms for the southern hemisphere. According to the observations heretofore made, it would appear that the southern snow-cap reaches furthest from the pole in about longitude 30° east of the first meridian.—*Abstract—Popular Science Review.*

[ACADEMY.]

SCIENCE NOTES.

Influence of Light on the Electrical Resistance of Metals.—It is well known that the electrical conductivity of the metalloids selenium and tellurium increases if they be exposed to the action of luminous rays, an effect the opposite of that which is produced when these substances are raised in temperature. Dr. Börnstein has shown (*vide Philosophical Magazine*, June supplement) that the same phenomenon occurs in the case of platinum, gold, and silver, and his experiments lead to the probability that sensitiveness to light is a general property of all metals. The metals experimented upon were reduced to such a form that the surface was very large in comparison with the mass, so that as much of the mass as possible was exposed to the incident luminous rays. The source of light was in most of the experiments a sodium flame, placed in front of the slit of a spectroscope with single prism. The metallic substance to be investigated was placed in a box-shaped enlargement made at that part of the telescope, belonging to the spectroscope employed, where the cross wires are usually situated, and could be included in a galvanic circuit by suitable arrangements. To avoid any risk of error, two different methods of measuring the resistance were employed—the measurement by the Wheatstone Bridge, and the measurement according to Weber's method of "damped vibrations." The results arrived at may be thus stated: 1. The property of experiencing a diminished electrical resistance under the influence of luminous rays is not confined to the metalloids selenium and tellurium, but belongs also to platinum, gold, and silver, and in all probability to metals in general. 2. The electrical current diminishes both the conductivity and the sensitiveness to light of its conductor, but both of these after cessation of the current gradually acquire their former values.

Suspension and Boiling of Water on Muslin Net with large Meshes.—If the open mouth of a glass bell-jar of any diameter from 20 to 50 centimètres be closed by means of a piece of coarse muslin, and then depressed into a vessel of water, the water may be drawn up into the bell-jar by aspiration through a tube passing through the upper portion of it. The bell-jar on being now raised out of the water is found to retain its contents, the muslin meshes thus performing the function of capillary tubes. At each of the meshes there is a well-marked meniscus. Capillary phenomena are largely modified by changes of temperature; nevertheless, a Bunsen's flame may be placed under the suspended water, and its temperature raised even to boiling without any of it escaping through the meshes. It will fall, however, if the ebullition be too violent. This interesting experiment was made by M. de Romilly (*Journ. de Physique*).

Diathermancy of Rock-Salt.—According to the experiments of Melloni and others, a plate of rock-salt one-tenth of an inch in thickness transmits more than 90 per cent of the radiant heat incident normally on its surface from copper heated to 400° C. A plate of ice of the same thickness transmits none of the heat which falls upon it under the same circumstances. Mr. J. R. Harrison describes, in the June number of the *Philosophical Magazine*, some observations he has made with rock-salt, from which he concludes that rock-salt is not diathermanous to the extent commonly supposed, but that, partially at any rate, it first absorbs the incident radiant heat, and then radiates it as from an independent source. His method consisted in enclosing one of two perfectly similar thermometers in a rock-salt case—the bulb not touching the rock-salt—and then placing the two, after they had been brought to the same temperature (0° C.), side by side in a tube surrounded by water at 100°. Both thermometers rose, but the enclosed one much more slowly than the other. Indeed, as the water cooled, the "naked" thermometer rose to a maximum of 71° in seven minutes, and then fell slowly, while the enclosed thermometer reached a maximum of only 64° in seventeen minutes. Thus for ten minutes the thermometer which was enclosed in the rock-salt case was being heated while the other was being cooled, which proves that the heat was not diathermanously transmitted through the rock-salt, but was first absorbed and then radiated out from it.

Thickness of Soap Films.—If a cylindrical soap film be formed between two platinum rings placed horizontally with one vertically beneath the other, the film will gradually thin under the action of gravity, and show the successive colors of Newton's series. Professors Reinold and Rücker, in a paper read before the Royal Society at the last meeting, have given an account of some experiments they have made on the thickness of films formed in the above-mentioned manner. The soap solution was that known as Plateau's *liquide glycerique*, consisting of oleate of soda and glycerine mixed in a certain proportion. A little potassium nitrate was added to improve the conductivity. After a short but varied interval from the time the film was formed, a black ring (the central color of Newton's rings as seen by reflected light) was formed at the top and was always separated by a sharp line of demarcation from the colored portion of the film. The experiments consisted in measuring the total electrical resistance of the film—which was effected by connecting the upper and lower platinum rings with one arm of the Wheatstone's Bridge—and at the same time noting the breadths of the black and of the colored portions of the film below the black. The thickness of air corresponding to these colors were known from Newton's table, and the thicknesses of the soap film for the same colors could be calculated when the refractive index of the solution and the angle of incidence of the light by which the colors were viewed were known. Thus the electrical resistance of the colored portion of the film could be calculated—assuming Ohm's law to hold good—when the specific resistance of the liquid used was known; and when this calculated resistance was subtracted from the total resistance of the film, as measured by the Wheatstone Bridge, the remainder expressed the resistance of the black portion. The conclusions to which the experiments led were the following: 1. The film increases in thickness enormously and with great rapidity at the boundary of the black and the colored portion immediately below it. 2. Below this line the increase in thickness is not uniform, but there are alternations of slow and rapid increase of thickness. The black is uniform in thickness whatever be its breadth, and is independent of the thickness of the colored portion of the film which appears to the naked eye to be in immediate contact with it. 4. The absolute thickness of the black portion—calculated on the assumption that Ohm's law holds good—is about twelve-millionths of a millimètre.

STREET REFUSE.

PROF. CHANDLER, president of the Board of Health of the city of New York, has given some interesting testimony as to the proper disposition to be made of the large amount of garbage and street-sweepings which is or ought to be collected in the process of cleansing great towns. In New York this question appears to be more serious than elsewhere, because the insulated character of the city seems hitherto to have left no practicable alternative as to the disposal of these foul masses when collected, except to empty them into the sea, there gradually to fill up the channels, or thence to be brought back by the tides, and washed ashore on the north and south sides of the harbor,—a most dangerous and objectionable result. This also involves great expense in the establishment and maintenance of numerous scows and tugs. An analysis of street refuse from thirteen widely separated and fairly representative districts in the city presented the following average results: of water, 3.032 per cent; of combustible matter, 28.454 per cent; of incombustible matter, 68.514 per cent; of nitrogen, 0,369 per cent. Prof. Chandler testifies that, if this organic matter were to be submitted to a heat of 112 degrees, the process of decomposition would be arrested; but that when the matter became moist again, decomposition would be resumed. A temperature of 500 degrees, however, would kill all animal and vegetable life in the mass; would render it perfectly harmless and as fit for filling-in purposes as fire ashes. Prof. Chandler, therefore, in the interest of public health, urges the establishment of a system of garbage cremation in furnaces similar to those used for the manufacture of shell-lime. One inventor claims that in his furnace, costing with all its appliances not more than $5,000, by the burning of three or four tons of cheap "slack," or coal-dust, two hundred tons of street refuse and garbage can be "cremated" and rendered innocuous in twenty-four hours. Some such system as this apparently would not only involve far less cost than the objectionable practice of conveying the sewage to deep water, as in New York, but would render the "dumping-grounds" of all great cities far more consistent with the just demands of civilization and public safety.—*American Architect.*

NEW ACID FROM "LECANARA ATRA."—E. Paterno and A. Oglialoro.—The lichen in question has been obtained from the mountains surrounding the western part of Palermo. The acid crystallizes from its boiling solution in chloroform in small, colorless, transparent crystals. It is very sparingly soluble in cold ether and alcohol, dissolves rather more freely in benzol and alcohol at a boil. It is slightly soluble in cold chloroform, and moderately in the same medium when hot. It melts at 190°, and its composition may be expressed by the formula $C_{19}H_{18}O_{8}$. It has the characters of a feeble acid.

HOME MANUFACTURE OF SUPERPHOSPHATES.

THIS is a question much discussed; but always with the idea that the farmer must adopt the same methods as the manufacturer. The danger and safety of using so powerful a chemical as sulphuric acid have been the basis of the discussions, and with small satisfaction for either side. We hold, that on general principles the farmer, unless he counts his labor little or nothing, cannot compete with the manufacturer who has every facility at his command. Especially is the farmer at a disadvantage when he has only coarse ground bones to operate upon, for such require a much larger amount of acid to cut them than if in fine condition, and a longer time. With ignorant labor in addition, the would-be home-manufacturer usually loses quite as much as he gains. As to the danger of using sulphuric acid, it is all bosh. A sharp ax is dangerous, and so is a bull. They both require care in handling; likewise with the acid.

But there is a cheap and efficient method at the hand of every farmer for utilizing refuse bones, or of making superphosphate of bone black, boughten bones, etc., and one which we have mentioned several times in these pages. The action of decomposing organic matter on bones is to break down their structure and render their phosphoric acid soluble, and to change the form of their organic portion so that the nitrogen in it is converted into forms readily available for plant food. This fact can be utilized with great comparative number of intelligent farmers of our acquaintance. The process in practice is as follows: Reduce the bones to as fine a condition as convenient; the finer, the quicker will satisfactory results be obtained. Mix them with three or four times as much stable dung; horse dung preferred. Have the pile beneath a shed to prevent washing, but keep it moist by frequent waterings with urine from the stables, if convenient, to keep up the heating of the mass, and to assist in the chemical processes as a solvent. If the heat is very great and ammonia is noticed escaping, scatter a thin layer of earth or plaster over the heap. An occasional shoveling over, say two or three times in the course of the time occupied, will be beneficial in more thoroughly mixing the ingredients, and hastening the decomposition. In from two to six months, according to the fineness of the bones at first, and the care and attention given during the time, the bones will be entirely decomposed, and the phosphoric acid reduced to the soluble form.

The same method is equally good for horn scrapings, wool waste, and other matters of a like nature which decompose with difficulty. An intelligent farmer of Franklin, Mass., made a compost of stable manure, wool waste, and crude bone black (burned bone). After two months a sample was sent to Prof. Goessman, who found that about one half of the phosphoric acid had been rendered soluble. In two months more, under similar conditions, it is not too much to expect that half as much more would be added to this amount. At the end of this period the nitrogen of the wool waste, through decomposition of the latter, will be set free and changed to an available form. When composting bones and stable manure, an addition of ashes to the mixture will be beneficial, both in furnishing needed potash to the resulting manure, and in hastening the process of decomposition. Thus a complete manure will be produced, good for any crop.—*Scientific Farmer.*

CLOVER.

EXCEPT the grasses no natural order of plants is of greater value to the farmer than the clovers. Successful cultivators in Central New York have long considered the use of clover, whether as pasture, hay, or manure, especially in combination with gypsum as a fertilizer, as the corner-stone of agriculture. Where the "soiling system" is adopted clover is a capital crop, since a good field is one of the very earliest ready to cut for fodder, which may be cut two or three times a year, while on rich land adapted to this system several tons may be cut to the acre each season, and leaving behind in the soil a mass of roots that, with a liberal manuring, form an excellent preparation for corn or wheat crops.

For hay this crop should be cut when about two-thirds of the plants are in full bloom and before becoming dead ripe, since then the starch and sugar will change to woody fibre, losing its feeding value and causing great brittleness and loss in the stalk and leaves. After cutting it should be allowed to thoroughly wilt in the sun, and with as little disturbance as possible; it should be cured mostly in the cock, as the leaves will be dry, while the stems are yet quite green, and rough handling causes great loss. As a hay crop clover is excellent for cows and sheep, but is less esteemed for horses. Green-clover hay, well cured, imparts flavor, aroma, and freshness to old fodder, and makes the mixture palatable to cattle. Green clover is better food for all animals than the hay made from it, since in the process of drying many of its vegetable particles are so hardened that the digestive organs have no longer any power to act on them; hence steaming clover hay softens and restores these hard particles, improving its feeding qualities. When fed to horses it should always be cut.

The growing of clover is almost equal to deep ploughing, because its long tap roots travel deeply in search of food for stem and leaf, while its large, broad leaves absorb ammonia from the atmosphere; hence, if ploughed under clover leaves, stems, and roots become very efficacious as fertilizers. Where a clover sod is desired for future grain or other crop it will be found that the cutting of clover is generally better than feeding it off, because every leaflet upwards has a rootlet downwards, and if a leaflet be taken off the rootlet will not grow, so that if sheep or pigs be fed upon the surface, the constant cropping of the leaves diminishes the under production. Always feeding the top will leave but few roots below. This was illustrated by a practical experiment on a field of clover, divided into two parts. The whole was cut in July; half was left to grow again, and the other half fed off. In October the roots of each division were dug up, carefully cleaned and weighed, with the result that showed a proportionate weight of three thousand nine hundred and twenty pounds to the acre where the clover was cut once and fed afterwards, while the part on which the clover was cut twice yielded at a rate per acre of nearly eight thousand pounds of roots. The system of cutting instead of feeding resulted in leaving two tons extra of vegetable matter, valuable in nitrogen, and which had a perceptible effect on the corn crop that followed.

Whether as pasture for sheep, swine, or cattle, green fodder for soiling milch cows, hay for winter use, green crop for ploughing under, or as a sod for future crops, the cultivation of clover demands increased attention at the hands of every progressive farmer.—*Boston Cultivator.*

POTATO CULTURE.

PROGRESS in practical agriculture must depend largely upon the deductions of careful experiment, and yet since each farm or section has its own characteristic soil, situation, and climate, the result of investigation and research, however skillfully worked out, cannot be made fully available to every farmer in the land except through the medium of his own observation and careful consideration of his own surroundings. Thus various experiments have been made and theories deduced on the subject of potato culture, and while each may have been faithfully and honestly performed, yet the results are quite opposite in their character. The value of such to the reflecting cultivator, who must after all decide for himself which road to take, consists in pointing out such discoveries as patient study and application have already developed, and in inciting a spirit of personal investigation into the cause and effect in the mind of every farmer in the land.

German investigators, we learn through a correspondent of the *Agricultural Gazette*, have been making numerous experiments on the best mode of propagating the tuber. Their first conclusion is, that a constant relation exists between the weight of the seed tuber and the vigor of the plant developed. The larger the seed tuber the earlier does the new plant attain a vigorous growth, and the heavier is the resulting crop. The increase of the crop more than repays for the increased weight of the seed. It follows, of course, from their theory, that large potatoes instead of small ones should be used for seed. When large potatoes are used the distance between the seed may be somewhat increased. The reason of this superiority of large seed is thus explained: During the period of early growth the plant derives its nourishment entirely from the mother-potato, and its vigor will depend on the amount placed at its disposal. If the early growth is vigorous, a hold is sooner obtained on the soil, and a larger and more mature crop is the result.

The second conclusion is that there is a great difference in the propagating value of the different eyes. The crown-eyes of the potato are the only ones which yield vigorous plants; the produce of the other eyes was found to be feeble and

unremunerative. If, therefore, potatoes are cut for seed, they should not (as is usual) be cut in their length, by which the crown is divided and eyes of all kinds introduced into the seed, but they should be cut across, the half containing the cross-eyes planted, and the other half consumed as food. The very best results are reported when large potatoes are taken, all eyes excepting those of the crown cut out, and the whole remaining potato planted. Stepler points out that the potato is an underground stem, and the crown-eyes the buds at the end of a branch; that the terminal buds of a branch are always far more vigorous than the lateral buds, any one may ascertain for himself by watching the growth of trees and shrubs in the early summer season. The degeneration of varieties of potato is believed by some of the German experimenters to be largely due to repeated propagation from small potatoes and feeble buds.

The two laws of propagation just noticed are strikingly illustrated by the experiments of Franz. His experiments, carried out in a garden soil, gave a crop per acre of four tons, where the seed used was tubers divided in their length; of seven and one-half tons with whole tubers as seed; of nine and three-quarters tons using the crown half of tubers; and of eleven and one-half tons to the acre where the seed was whole tubers, eyes other than crown removed. Several other experimenters in the same line all conclude that whole tubers yield a much higher produce than tubers divided in their length; also that the crown half of the potato yields a decidedly larger crop than the half obtained by division through the length; but they do not, like Franz, find that the crown half is generally superior to the whole tuber.

Another recommendation made is to expose the seed freely to light and air before sowing. Heiden and others conclude that the best distance for planting, in medium soil, is twenty-eight inches between the rows and fourteen inches between the seed. Their results show that both the total crop and the percentage of large tubers are increased by wide planting up to this limit, of course varying with the character of soil and manures, as well as of the size of the seed used.

Drechsler has some field experiments on the effects of over-heaping the soil upon the young plants. The seed had been sown on April 21; at the beginning of June the rows were earthed up, each alternate row being completely covered with earth, so that the vine was not visible. The crop was harvested in October, when the over-heaped rows gave a less crop by nearly seven tons per acre. In another experiment, in which the earth did not quite cover the top of the vine, the deficiency from this over-heaping was about two tons to the acre. With the potato—as with every other plant—a vigorous growth of leaf is an essential condition for the production of a large crop. With the exception of the ash constituents, derived from the soil, all the matter stored up in the tuber is first formed in the leaf and thence transferred to the underground organs. Any treatment hindering the leaf growth is an injury to the crop.—*American Cultivator.*

ECONOMIC PLANTS IN JAMAICA.

A VERY full report on the condition and progress of the botanical gardens and public plantations in Jamaica has been issued. This report treats largely of the cultivation and distribution of various important economic plants. In a coffee-growing country like Jamaica, the consideration of the introduction of the now celebrated Liberian coffee is a matter of great interest. This valuable coffee, which has recently been described and figured under the name of *Coffea liberica*, was introduced to Jamaica in 1874, and the plants were at first treated in one of the cinchona propagating houses, where the temperature was higher than in the open air. They soon attained a remarkable vigor, producing foliage several times larger than the common coffee. Soon after these plants were imported, about thirty of them were distributed among coffee planters, and placed in a variety of altitudes; the result of this was to prove that those grown at the lower elevations attained the greatest success. As an instance of the rapid growth to maturity of this kind of coffee, it may be mentioned that a plant, only a little over a year old, that had been planted out at an elevation of about 1,000 feet above the sea, produced fruit. There is every reason to believe that during the present year the Liberian coffee will be largely increased from seeds. The most promising feature about its cultivation in Jamaica is its adaptation to the condition of climate existing at low altitudes. The common coffee is the most accommodating of all cultivated Jamaica products, inasmuch as it is grown at all heights, from the sea-level up to 5,000 feet. The superior qualities of coffee, however, are only produced at heights ranging above 2,000 feet; below that elevation the quality of the produce decreases in value as it approaches the level of the sea. Hence, as regards the production of good quality, the lower limit of cultivation is about 2,000 feet. As the peasantry, who are now the largest producers of coffee in the island, almost exclusively cultivate their coffee under 2,000 feet, and as the cultivation of the plant has been largely increased by them in recent years—in which time they have planted several thousand acres—the acquisition of a species especially adapted to the climate of the lowlands is a matter of great importance.

Notwithstanding the fact that the Jamaica plantation coffee is the finest in the world, no new plantation has been established for a long series of years. On the contrary, there is a gradual diminution in the area under coffee cultivation on large plantations. The soil in the Port Royal Mountains, in which all the famous coffee is grown, is becoming more and more impoverished from year to year, and all the land adjacent to these coffee plantations has been, in great measure, exhausted by coffee cultivation, so that there is very little available land to work upon in their immediate proximity. The coffee-fields in question are all confined to the southern slopes of the Blue Mountain range. The northern slopes, except near the sea, on the other hand, are covered with dense primeval forest, no attempt having been made in this new and extensive field to undertake the cultivation of this important plant, although these lands are by far the most valuable in Jamaica for coffee cultivation. Most fortunately, during the past few years, the Government has enacted a law whereby nearly all the said lands on the northern slopes have been forfeited to the Crown from non-payment of quit-rents. It is, therefore, of great importance that these precious lands should be reserved by the Government for the future expansion of coffee cultivation, as well as for other important products requiring a similar condition of climate. With enterprise and capital, this virgin soil is capable of yielding coffee that would vie with the famous returns obtained in Ceylon during its palmiest days of production. Thus the marked contrast between the scanty crops now obtained from the worn-out fields of the Southern slopes of these mountains, and the crops obtainable in the fertile regions on the other side, will, some day, there is every reason to believe, attract private enterprise to embark in the extension of this agricultural industry. It is important, however, to bear in mind that the conditions of humanity are remarkably different respectively on the northern and on the southern slopes of these mountains; on the latter side the wholesale destruction of the forest for coffee cultivation has naturally lessened the rainfall and other conditions of the moisture, thus rendering the climate comparatively dry, and, therefore peculiarly fitted for the successful cultivation of coffee. Under the influence of the dense forest the conditions of humidity are perfectly different. Thus, to create a climate suited to the wants of the coffee plant, the extensive clearance of the forest is absolutely necessary.

The area of land eminently favorable for coffee on the unoccupied locality in question, including a considerable area of forest-covered land on the eastern prolongation of the southern slopes, may be roughly estimated at from 60,000 to 80,000 acres, nearly all of which belongs to the Government. The total area in the island now under coffee cultivation, most of which is at unsuitable elevations, is 22,000 acres. With regard to the export of coffee from Jamaica, it seems that the United States of America are becoming very large customers for this commodity, the quantity exported to North America increasing at a much more rapid rate than are the exports to England. The best quality of coffee, however, is not sent to America. Though not an important commodity from Jamaica at present, cocoa (*Theobroma cacao*) next claims attention in the report under consideration. As is well known, Trinidad is one of the head quarters of cocoa cultivation, and from this island some of the best varieties of cocoa have been introduced to Jamaica with a view of establishing the plants for extensive cultivation. Seeds were taken from Trinidad in 1873, and planted at Castleton, and the plants so raised are now beginning to bear fruit. A good deal of attention has been paid to the propagation of these plants, which are being increased as rapidly as possible. Though Jamaica grown cocoa has hitherto been of very poor quality, there seems no reason why it should not take a high place, as both climate and soil are reported to be extremely favorable to the production of a superior quality; moreover, the writer of the report says: —"As the Government has favorably entertained the advisability of promoting its cultivation it has occurred to me that this could be most certainly accomplished by offering prizes to the peasantry for the establishment of, say, every two acres containing a given number of plants, the prizes to be awarded as the plants arrive at the age of two or three years." In Trinidad, the numerous varieties of cocoa are known chiefly by the shape or form of the fruit, its size or color; some are more spherical, and some more oval than others, some again are plain, others are marked with distinct longitudinal ribs, varying likewise in number. In some varieties the color, when ripe, is of a bright yellow, while in others it partakes of a reddish tinge. The best kinds for commercial purposes are well known to the growers, and these kinds were selected for trial in Jamaica. Next, perhaps, to coffee, the sugar-cane is the most valuable of all Jamaica products. Many useful varieties of this important grass have been introduced of late years from the Mauritius plantations. For the selection of suitable varieties, and their proper cultivation, many important conditions of soil and climate have to be ascertained. "Certain varieties are peculiarly adapted to humid conditions of climate, and other varieties are equally adapted to withstand droughts of considerable duration. Thus, in selecting a given variety for a dry part of the country, it is important to select one that produces a profusion of luxuriant foliage, which, densely covering the earth, intercepts excessive evaporation; the inherent nature of the cane itself also accommodates it to the circumstances in which it is placed. The conditions that are, therefore, necessary to establish the relative value of the new canes are so varied, that great care and discrimination have to be exercised." Systematic selection of the varieties likely to be of permanent value are being planted in the island, and a large number of cuttings of various kinds have also been sent to different parts of the island. The report points out the great importance of the introduction of new varieties, because the prolonged and excessive cultivation of any variety conduces to its deterioration, and, further, often engenders diseases. The few varieties of sugar-cane now mostly cultivated in Jamaica have been so cultivated from time immemorial; therefore, to perpetuate its superiority, as well as to increase its saccharine richness, it is most important that valuable new varieties should be introduced. Of the newly imported canes, the Salangore is said to be the most noted, and of this variety there are, at the present time, hundreds of acres in all parts of the island. One planter has, of this particular kind, about 160 acres under cultivation, all the plants being raised from a single cutting obtained from the Castleton garden some four years since.

On the subject of pine-apple cultivation, the report says: —The plantation—embracing about four acres of this plant—formed at Hope three years ago, with the object of awakening private enterprise to an interest in this cultivation on a large scale, especially to meet the wants of the American market, progressed very favorably; indeed, for pine-apple plants, they attained an unusually vigorous growth until about nine months since, when some of the plants began to die off without any premonitory symptoms, and for several months the number of losses gradually increased. On examination being made as to the cause of this mortality, it was readily traced to the soil. It should be stated that all the soil at Hope is of a gravelly nature, but the rich surface soil in which these pines were planted was somewhat tenacious of moisture, especially after the continuous rains; the pine-apples were also flooded for about two days by the bursting of the conduit that supplies the Hope reservoirs. Before the loss of plants became large, they were removed to a more porous soil a few hundred yards off. In the operation of transplanting further loss was sustained, so that probably not more than half have survived. There is no doubt, as indicated in the foregoing remarks, that the excessive wet year has had a prejudicial influence on these plants, but the cause of the mortality amongst them was chiefly due to the too tenacious soil. It is well, therefore, to warn intending growers of this valuable plant of its extreme impatience of dampness at the roots, hence the necessity of selecting soil of a sufficiently gravelly nature to ensure its being freely permeable to rain.

A good deal of attention has been paid to the cultivation of useful timber trees, foremost amongst them being teak (*Tectona Grandis*). Seeds have been sown and plants raised, about fifty of which were planted out two years ago, and since that period about 500 more have been so planted. At the present time the teak plants occupy an area of about ten acres, and it is gratifying to learn that these trees have made remarkable progress, the majority of them having in little more than a year attained a height of from ten to twelve feet. One tree is reported to be yielding seed so abundantly that thousands have been sown and are now being propagated. Of the Divi-Divi (*Cæsalpinia coriaria*), a well-known tanning plant, about seven acres are under cultivation, containing 450 plants. The cultivation of the pindar or ground nut (*Arachis hypogæa*) has, it seems, been nearly abandoned for several years, but it is being now again restored by the negroes.

That most important of all tropical trees, the cocoa-nut, whether we consider the multitudinous use of its products, or its value in giving effect to tropical scenery, is, it seems, being very extensively planted in Jamaica. In the plantation known as the Palisadoes, upwards of 18,000 trees of *Cocos nucifera* are now being planted; the bulk of these, however, are small plants at present, but hundreds of those that were planted previously are now beginning to bear fruits, so that in the course of a few years large crops may be expected, more especially as it is intended to increase the plantation to a total number of about 25,000 plants. One great desideratum seems to be the introduction of suitable machinery for expressing the oil, and this necessity is pointed out to the Government with the hope that they may take the matter up. A descriptive account of the manufacture of cocoa-nut oil and coir by improved machinery, as carried on in an extensive manufactory of Trinidad, is given, from which it seems that a thousand kernels or fruits yield twenty-five gallons of oil, the manufacture of each gallon costing eightpence, so high is the price of labor. Coir is manufactured only to a limited extent, vast quantities of the husk being left to decay everywhere. The crushing and separating of the fibres of the husk is effected first by passing it through a powerful mill, and afterwards passing it through a kind of combing machine, firstly of coarse, and afterwards of fine teeth. About six hundred husks give about one hundred pounds of fibre, which one man can prepare in the course of a day. Like most useful plants, the cocoa-nut is liable to disease about which little seems to be known, but the general opinion was that it was due to some insect. In Demerara, recently, the cocoa-nut groves have been fearfully devastated by the attack of a small beetle (*Passalus tridens*), and it is very probable that the disease referred to in the Jamaica report is identical with that of Demerara. It is to be hoped that decided measures will be taken to prevent the increase of these pests.

In the matter of medicinal plants, the cinchona plantations occupy the first notice. Eight years have elapsed since the first planting out of cinchonas took place at the Government plantations in Jamaica. *C. officinalis*, *C. succirubra*, and *C. calisaya* are the species mostly cultivated. Of the former, the tallest tree at the present time is 33 ft. 8 in. high, with a circumference near the ground of 25 in., the bark being ¼ in. thick. Of *C. succirubra* the tallest tree is 31½ ft. high and 26 in. circumference, 18 in. from the ground, and the bark slightly thicker than the last. The tallest trees of *C. calisaya* are about 25 ft., the trunk and bark of similar thicknesses to preceding. *C. succirubra*, with its varieties, seems to be the plant which thrives best; of this, in the several plantations, at different aspects and altitudes, there are under cultivation about 50,000 plants, of *C. calisaya* and its varieties nearly 20,000. The cinchonas, though so flourishing, and though self-sown seedlings are constantly appearing in large numbers in the plantations, have shown signs of disease, almost exclusively amongst the seedlings, vast numbers of them perishing soon after germination. If propagated from cuttings, this mortality is considerably lessened. "There is still sufficient land cleared of forest for the extension of the plantations, in which to set some 20,000 plants, in addition to what have been propagated, and it is expected that this number will be prepared before the end of 1877. From a tree of *C. succirubra*, 25 ft. high and 18 in. in circumference near the ground, which was felled in the spring of last year, four pounds of dry bark was procured; but the bulk, or weight, of bark is largely increased by allowing the trees to live to an age of, say, 16 years, rather than denuding them of their bark at eight years;" thus "a tree, instead of being cut down at eight years old, and yielding three pounds of bark, would, at the age of 16 years, yield 16 pounds. It should also be remembered that bark 16 years old contains a considerably larger proportion of alkaloids than the younger tree, hence its greater commercial value. Again the older bark would shrink less in weight in the process of drying than a less matured bark." The branches of the cinchonas not being of a spreading habit, it is recommended to plant them only about 12 feet apart, at which distance the number of plants to the acre would be about 300. Calculating each tree to produce about 16 lbs. of bark, and the price realized to be 3s. per pound, the value of sale would be £2 8s. or a little over £724 per acre, and allowing for unseen causes, which perchance might diminish the yield by one half, or £350 per acre, "the actual cost of establishing and cultivating for a period of sixteen years would not, at the highest computation, including all expenses and interest on capital, exceed £60 per acre." After the practical experience which the superintendent of the Botanic Garden has had in the cultivation of these valuable plants it is satisfactory to read his concluding remarks under this head, which are as follows:—"It has been abundantly proved that several species of cinchona are eminently fitted for cultivation in Jamaica. The enterprise has emerged from the purely experimental state, and can be now carried on as an established agricultural industry. Capital and enterprise are alone wanted to ensure the extension of the cultivation on the salubrious Blue Mountains. It is also a matter of consideration of the Government to determine the advisability of extending this cultivation on the extensive tracts of land in the possession of the Government on these mountains. In this manner one hundred acres of *C. succirubra* or its varieties might be planted annually.

Attached to the cinchona plantation is a piece of land of nearly two acres extent, occupied by another medicinal plant, namely the Jalap (*Exogonium purgum*); a crop of 1,700 lbs. of this drug was obtained during the year, and it was estimated at the time this report was written that 3,000 lbs. more would be obtained in the course of a few months, which would be exported to England.

That the climate of Jamaica is suited to the growth of the now celebrated *Eucalyptus globulus* is evidenced from the fact that in a little over six years, when the seeds were first introduced and planted, the trees have grown to a height of sixty feet with trunks a foot in diameter; some thousands of plants of this species have been distributed in the island and planted chiefly in the lowlands where, however, contrary to the general expectation, they have not been successful, thus demonstrating against the popular belief of their suitability for general cultivation in tropical lowlands. The value of this species as a timber tree is very great, not only on account of its rapid growth, but also on account of the straightness, evenness, and durability of the wood.

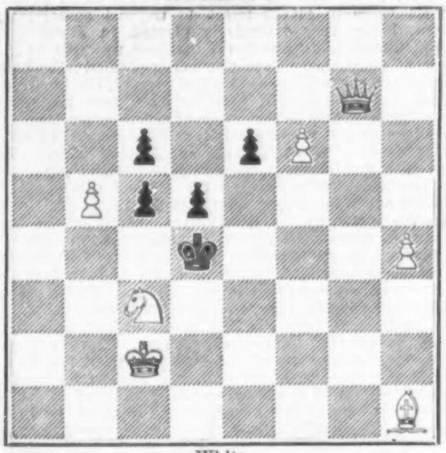
SCIENTIFIC AMERICAN CHESS RECORD.

[All contributions intended for this department, may be addressed to SAMUEL LOYD, Elizabeth, N. J.]

PROBLEM No. 3.—BY SAMUEL LOYD.

Prize for the Best Problem of the Tournament.

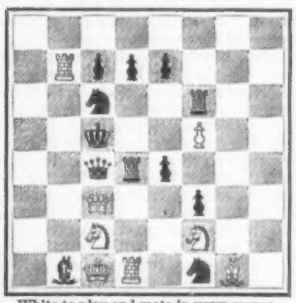
Black.



White.

White to play and mate in four moves.

CENTENNIAL PROBLEM TOURNAMENT.



White to play and mate in FOUR moves.

ESPECTFULLY introducing myself to our readers at this early stage of my editorial career that we may become the better acquainted, I also take this opportunity of giving selections from the recent Centennial Problem Tournament, in which I was so fortunate as to carry off the lion's share of the prizes. This tournament was gotten up on the spur of the moment after the conclusion of the Centennial Playing Tournament, and when we consider the short time allowed for competition, it met with a most marvelous success, there being upwards of three hundred problems entered, the greatest number, I believe, ever entered in a Problem Tournament. The affair was under the united management of the Chess Editors throughout the country, who offered the following seventeen prizes, competitors being invited to send as many problems in competition as they desired.

For the best set of three original problems, consisting of two, three or four move problems, a prize of	$50 00
For the second best set, a prize of	25 00
For the third best set, a prize of	12 50
For the best single problems, of 2, 3 and 4 moves, three prizes, each	10 00
For the second best single problems, 3 prizes, each	5 00
For the third best single problems, 3 prizes, each	2 50

Also an additional prize for the best problem of the tournament, and special prizes for the best problem contributed to the Boston *Globe* and Cleveland *Sunday Voice*, besides two prizes for the best problems in the form of letters.

The following is the flattering record I received from the umpire May 31, 1877:

Best problem of the tournament, about	$141
Best set	50
Second best set	25
Best two, three, and four	30
Second best four	5
Sunday Voice trophy	10
Boston *Globe* trophy	50
First prize, letter problem	23
Total	$334

The other prizes were awarded as follows:

Third best set—Jacob Elson	$12 50
Second best three move problem—Jacob Elson	5 00
Second best two move problem—Harry Boardman	5 00
Third best two move problem—J. B. McKim	2 50
Third best three & four move problems.—J. H. Finlinson	5 00
Second prize for letter problem—L. W. Mudge	11 50
Total	$41 50

I give as a selection of my problems, the R which carried the first letter prize; the four mover which won the prize for the best problem of the tournament, from the first prize set, and the three mover from second best set, to which was also awarded first prize for best three move problem of the tournament. A new tournament will shortly be put on foot, when it is to be hoped that the programme will be arranged so that no one competitor can carry off both first and second prizes.

The Committee on Articles and By-Laws of the New Chess Association have just handed in their report, as follows, from which it will be seen that there have been but few changes made from those adopted at the first American Chess Congress of 1857.

ARTICLES.

I. This Association shall be known as the American Chess and Problem Association.

II. The officers shall consist of a president, two vice-presidents, secretary, and treasurer, who shall be elected at the annual meetings of the Association, and shall hold office until such times as their successors shall be elected.

III. There shall be a general committee consisting of all the Chess Editors throughout the United States, who shall appoint an executive committee of five members, residents of different sections of the country.

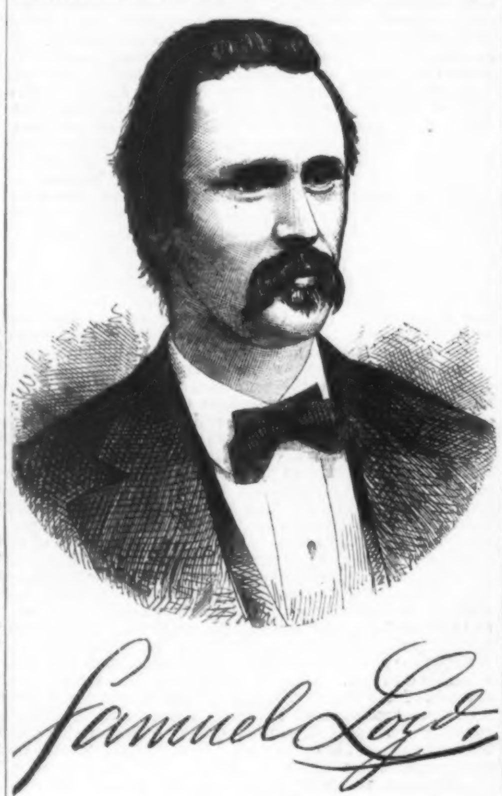
IV. The congress of the Association should be held as often as once a year, unless an adjournment be decided upon at the time appointed for such annual meeting. The time and locality of meetings, as well as all rules and regulations of the tournaments, shall be subject to a majority vote of the Association.

V. The annual dues shall be one dollar for each member, payable at the time of becoming a member, and on each succeeding month of January.

VI. All monies received from dues and subscriptions shall be offered in prizes for competition; and there shall be two funds set apart for this purpose, the one for games, the other for problems.

At the time of contributing or paying dues the donors have the option of selecting to which of these funds they desire such monies to be appropriated.

Our chess friends, desiring to become members, may forward their names and fees direct to the treasurer, Dr. C. C. Moore, 68 and 70 Courtlandt St., New York. S. L.



STEINITZ *vs.* BLACKBURNE.

The following game is selected from the match between Steinitz and Blackburne, played at the London West End Chess Club, Feb. 17th, 1876, for the sum of £120. The winner of the first seven games, exclusive of draws, to be declared the victor. The time limit being fifteen moves an hour for each player. Much interest was occasioned by this match for the reason that Mr. Steinitz had won the first prize at the Vienna Tournament, and had only beaten Mr. Blackburne—who scored second prize—by a very small majority.

The result of this match, however, proved conclusively Mr. Steinitz to be the best player, or that Mr. Blackburne was not up to his usual play. The result being an overwhelming victory for Steinitz by a score of seven to nothing, not even allowing his opponent the satisfaction of a single draw.

(RUY LOPEZ.)

WHITE. Steinitz.	BLACK. Blackburne.
1. P to K 4	1. P to K 4
2. Kt to K B 3	2. Kt to Q B 3
3. B to Q Kt 5	3. P to Q R 3
4. B to R 4	4. Kt to K B 3
5. P to Q 3 (*a*)	5. P to Q 3 (*b*)
6. P to Q B 3 (*c*)	6. B to K 2 (*d*)
7. P to K R 3	7. Castles.
8. Q to K 2	8. Kt to K sq
9. P to K Kt 4	9. P to Q Kt 4
10. B to B 2	10. B to Q Kt 2
11. Q Kt to Q 2	11. Q to Q 2
12. Q Kt to B sq (*f*)	12. Q Kt to Q sq
13. Kt to K 3	13. Kt to K 3
14. Kt to K B 5	14. P to K Kt 3 (*g*)
15. Kt x B ch	15. Q x Kt
16. B to K 3	16. K Kt to Kt 2
17. Castles Q R	17. P to Q B 4
18. P to Q 4	18. K P x Q P
19. P x P	19. P to B 5 (*i*)
20. P to Q 5	20. Kt to B 2
21. Q to Q 2 (*j*)	21. P to Q R 4
22. B to Q 4	22. P to B 3
23. Q to R 6	23. P to Kt 5
24. P to Kt 5	24. P to B 4 (*k*)
25. B to B 6	25. Q to B 2
26. P x P	26. P x P
27. P to Kt 6	27. Q x P
28. B x Kt	28. Q x Q ch
29. B x Q	29. R to B 3
30. K R to Kt, ch	30. R to Kt 3
31. B x P	31. K to B 2
32. B x R, ch	32. P x B
33. Kt to Kt 5, ch	33. K to Kt sq
34. K R to K sq	34. Resigns.

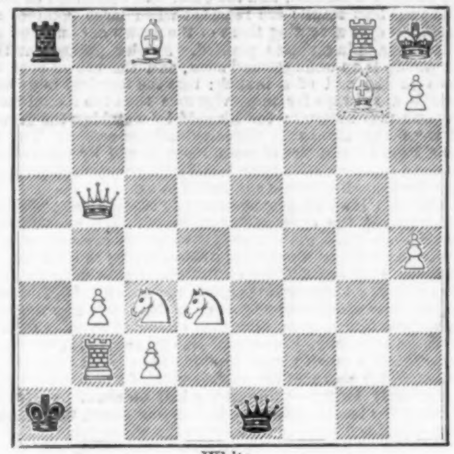
[Duration five hours.]

(*For Notes, see next column.*)

PROBLEM No. 4.—BY SAMUEL LOYD.

Prize for the Best Three-move Problem of the Tournament.

Black.



White.

White to play and mate in three moves.

NOTES BY MR. STEINITZ (*on Steinitz vs. Blackburne*).

(*a*) Anderson in his match against Morphy first adopted this move, which, at the time, caused a great deal of animadversion among theorists, who were inclined towards advocating a more energetic attack than the nature of the opening apparently can bear. But we believe that the great German master showed a true appreciation of the spirit of this opening, which requires a treatment similar to that of the close game, namely, a steadfast gradual development, content with the small advantage of the first move.

(*b*) Morphy played here invariably P to Q Kt 4 followed by B to Q B 4; the move in the text was first brought into practice by Paulsen, and was afterwards accepted as the standard defence, which in the majority of games hitherto played has proved successful.

(*c*) Anderson prefers here B x Kt, ch., and then directs his attention to retaining both his knights, and preventing the adversary from dissolving his double pawn. White here pursues a different, and in the present position novel, policy, and makes preparation for retaining his K B, and resting his game upon confining the opponent's K B. Whether this plan is an amelioration of Anderson's line of attack can only be proved by repeated practical trials.

(*d*) Against Anderson's form of attack in this *debut* it is more usual to open an outlet for this B by P to K Kt 3. Black prefers to get his K into safety as soon as possible, and therefore at once makes room to enable him to castle.

(*f*) This peculiar way of bringing the Kt over to the K side was first introduced by Morphy as first player in a K Gambit declined, played against Mr. Bird. It afterwards occurred in a game played by Steinitz against Blackburne in the Vienna Tournament. But on all those occasions this singular course was elected after the Q B had been brought out; while here White seemed to have time for this manœuvre, even at the cost of temporarily blocking out his Q B.

(*g*) For pure defensive purposes it would have been feasible to retreat the B to Q sq.: but Mr. Blackburne thinks that after the exchange, and since his adversary was compelled to castle on the Q side, the chances of an attack were at least equally balanced for both sides.

(*h*) The B supported at this post the subsequent advance of the Q P, which freed White's game. The move adopted is stronger than the move attacking B to R 6, which would have subjected White to the following counter attack:

16. B to R 6	16. Kt from K sq to Kt 2
17. Castles Q side	17. P to K B 4
18. Kt P takes P	18. P takes P and the B

is badly posted, being exposed to the attack by Q to B 3 or R to B 3.

(*i*) Mr Blackburne pointed out that P to Q 4 would have been much stronger at this juncture, and there can be no doubt that this move would have much improved his game. White's best answer then would have been to advance the P to K 5, for if P x Q P instead, Black would rejoin Kt to K B 5, with an excellent game. Most likely the game would have proceeded thus:

	19. P to Q 4
20. P to K 5	20. P to Q 5

21. P to K R 4, and now, whether Black advanced the P to K B 4 or P to K R 4, White retained still some considerable attack; in the former case by P x P *en passant*, followed by Kt to K 5, and in the latter case by the answer of Kt to Kt 5, followed soon by P to K B 4. But, nevertheless, Black has a better chance then of repelling the onslaught, and certainly, if he once got out of the attack, even at the expense of sacrificing a piece eventually, his fine array of well supported pawns on the queen's wing would have been most formidable.

(*j*) A move necessary for defensive purposes, but also threatening. Before moving the Q, White could not utilize his Q B without subjecting his Q P to capture. Now White menaces to break in with the Q, either at Q R 5 or at K R 6 after removing the B, as actually occurred.

(*k*) Perhaps K Kt to K sq. with the intention of offering the exchange of queens at K Kt 2, would have augmented Black's prospects of prolonging the fight; but, even if he succeeded in effecting the exchange, White's pieces and pawns were better situated for the end game, *e. g.*:

	24. Kt to R 4
25. P to K R 4	25. Q to Kt 2
26. Q x Q, ch	26. Kt x Q
27. P x P	27. Kt to K R 4
28. Kt to Kt 5	28. Kt x B P

29. P to R 5 with a fine attack, for, if Black's Kt take the R P, White would sacrifice the R for the Kt followed by R to Kt sq, upon the opponent retaking the R, and winning easily.